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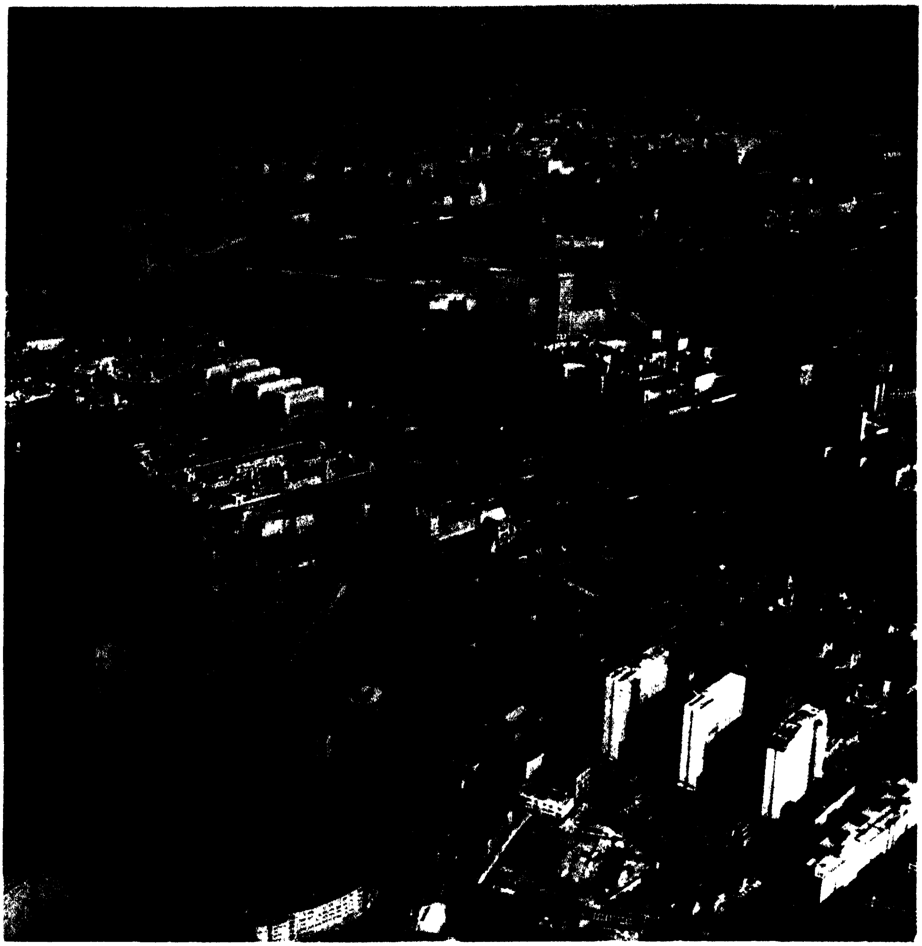

**Modern London**

An air view looking northeastwards down the river Thames. In the centre foreground is Westminster Abbey with the Houses of Parliament to the right. Left foreground the dome of the Methodist Central Hall and numerous government buildings on each side of Whitehall. The bridges are Westminster, Charing Cross (railway), Waterloo and Blackfriars. Across the river are the County Hall (headquarters of the Greater London Council), Waterloo Station and the 1962 skyscraper of Shell Centre. In the centre distance St Paul's Cathedral can just be seen.

# The British Isles

*A Geographic and Economic Survey*

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and

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# Contents

# Preface to the sixth edition

The death of Sir Dudley Stamp in 1966 deprived this book of its senior author and certainly delayed the production of this sixth edition. The writing of economic geography becomes increasingly difficult in this age of rapidly changing technology and fluctuating economic progress, and when in addition nearly two years may elapse between the completion of a revision and its publication the task of keeping a book up-to-date is almost impossible. So much has happened in Britain since the fifth edition was prepared in 1962, that certain sections of the book have had to be completely re-written; and some re-arrangement of the material has been undertaken as well. A new chapter on Fuel and Power includes the former chapter on Coal plus sections on gas, coke, thermal and hydroelectricity that were formerly scattered through other chapters. The chapter on Chemical Industries has been completely re-cast.

I am grateful to various friends and colleagues for substantial contributions to the new text. Professor J. T. Coppock has completely revised the chapters on Agriculture, Mr Trevor Thomas re-wrote the section on Coal, and Dr T. D. Kennea re-drafted the Fisheries chapter. Mr T. W. Freeman gave much good advice on the chapters relating to Ireland. Mr S. W. Rogers assisted in the revision of the Forestry chapter. Professor I. T. Millar helped me to sort out the problems of the chemical industries.

Other chapters to which substantial alterations, necessitated by changing technological and economic circumstances, have been made, are Iron and Steel and Miscellaneous Industries. The Textile chapters presented a special problem in that, especially in Lancashire, these industries have altered almost beyond recognition through contraction and the substitution of man-made fibres. So the chapters on Cotton and Wool have been left as studies in historical geography, with additions explaining some of the modern developments.

Over sixty new maps and diagrams have been included, and for the drawing of these I am indebted to my technical staff, Mr G. Barber and Miss E. Smith. The resources of the Statistics Library at the London School of Economics were tapped for me by Mr L. Baker, whose help is gratefully acknowledged.

This edition appears at a time when the process of metrication is in full swing. At the risk of cluttering up the text with figures, it has been felt

advisable to give English equivalents in brackets after the metric measurements. Perhaps when the seventh edition is called for, students and the public at large will be sufficiently familiar with the metric scales to allow the English equivalents to be dropped.

*Keele* S. H. BEAVER
*August 1970*

# Acknowledgements

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Aerofilms Library Ltd: Frontispiece and Plates 20, 21, 23–25, 29–31; Peter Baker: Plates 6, 8, 27; Barnaby's Picture Library: Plates 16, 28; V. Blankenburgs: Plate 2; British Petroleum Co. Ltd: Plate 32; British Railways: Plates 26, 33; British Steel Corporation: Plates 17, 19; Central Electricity Generating Board: Plates 11, 12; The Forestry Commission: Plates 1, 3; National Coal Board: Plate 9; North of Scotland Hydro-electric Board: Plate 13; John Topham Ltd: Plates 4, 5. Plates 14, 15, 18 and 22 are by S. H. Beaver.

# 1
# The position of Britain

No philosophy of British history can be entirely true which does not take account of the facts of the position of Britain. So wrote Sir Halford Mackinder over half a century ago in that book *Britain and the British Seas*, which must for ever remain a landmark in the progress of thought in this country, for it marks an important stage in the resurrection from the dead of the forgotten or discredited science of geography—the study of the earth as the home of man and of the interrelationship between man and his environment. It will be the purpose of this book to examine the natural environment afforded by the British Isles for their human inhabitants; to examine the advantages and the disadvantages of that environment; to analyse the natural resources of value to man which are proper to these islands; to see the use which the inhabitants have made of those resources, and so to lead up to a study of the present position—the capital which has been accumulated in consequence of past exploitation, and the outlook for the future in the utilisation of the resources which remain.

The philosophers of ancient Greece knew well that the earth was a sphere, and 'every schoolboy knows' of the experiments of Eratosthenes by which the actual size of the sphere was measured. But the known world of the ancients occupied but a small portion of the surface of the sphere. It centred round the Mediterranean Sea. To the south it was bounded by the Sahara, beyond which there were but legendary lands. On the southeast it extended to the Indian Ocean, to the east so far as Central Asia, beyond which again lay the mysterious land of Cathay known only because of the silks and porcelain brought by traders to Mediterranean Europe. On the northwestern margin of the known world lay the islands of Britain. The name 'Albion', which is still sometimes applied to the larger of the two islands, perpetuates the point of view of the ancients. The British Isles were approached and explored from the Continent, and it was the white chalk cliffs of Dover, facing as they do the land of Gaul, which suggested a name for the whole country. The Celtic lands of Ireland, Wales and Scotland lay on the outermost fringe, so little known that in many of the ancient maps Scotland is represented as an island. Throughout early Christian or medieval times the marginal or terminal position of the British Isles became accentuated as the scientific concepts of the ancients became lost during the Dark Ages. The fantastic maps of the medieval monks show

Jerusalem as the centre of a flat earth separated by the blue curtain of the sky from the celestial Jerusalem above, but again with the British Isles on the margin and doubtless near the dangerous 'edge' of the world.

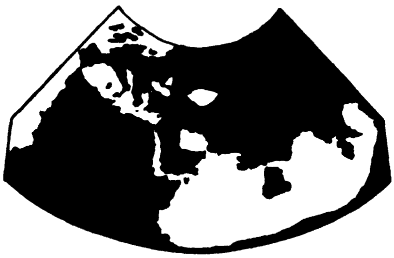


FIG. 1. Map showing the terminal or marginal position occupied by Britain in the world as known to the ancient Greeks and medieval geographers. (*After Ptolemy*)

The year 1492 not only marks the discovery of the Americas by Columbus, but it marks the end of the dominance of the countries of the Mediterranean basin. It released the British Isles from the disadvantage of being on the fringe of world politics and placed London in the centre of the land of the globe, and the British Isles in a dominating position relative to all the world. This reorientation was not the result of an accidental discovery. Columbus's voyage was based on a firm belief that the earth was a sphere and that it was consequently possible to sail round it. Anyone holding such a view at that time did so not only in opposition to public opinion but also in constant danger of being branded 'heretical'. One may wonder why the land on the far side of the Atlantic remained so long unknown to Europeans.


FIG. 2. The world position of Britain today—the centre of the 'land hemisphere'

True the coasts of Greenland, of Labrador, and of Newfoundland were doubtless known at a much earlier date to Icelandic and Norwegian fishermen; but however attractive the fisheries might be, the character of the lands was not such as to cause enthusiastic wonder. Flowing southwards, parallel to the coast of Greenland, is a cold current bearing a constant stream of icebergs from the Arctic, and whilst a vessel may sight land, the crossing of this belt of cold water and actual landing on the shores is a matter of extreme difficulty, and climatic conditions are obviously not those to attract such attempts. The navigators of the Mediterranean, a sea which, with its great extent and its treacherous sudden storms, was no mean school for navigators, knew that when they passed through the Pillars of Hercules, or the Strait of Gibraltar, and turned southwards they were in the belt of the constant northeast trade winds, that would always blow them *from* known lands and would allow the venturous mariner no hope of return. Over the north of France and the south of Britain, the winds, though variable, were on the whole from the southwest; but to venture with a sailing vessel of a few tons, which could be victualled only for a limited period, merely to test the theory that one could go outwards by the northeast wind, and at some far distant point find it possible to get in the current of wind which was on the whole southwesterly, required the efforts of a dominating and fearless leader, and Columbus's own sailors nearly lost faith in their leader before land was sighted. Once the discovery had been made no one can fail to be impressed by the rapidity of events which followed—the exploration and settlement of the American continent—and by the consequent opportunity afforded to those countries of Europe which faced the Atlantic and of which the British Isles formed one. The Mediterranean became a backwater, its commerce and its cultures decayed, and it was not until 1869–70 that the opening of the Suez Canal afforded a resuscitation of its ancient trading glory. By that time the world position of Britain was too firmly established to be shaken by the revived importance of the Mediterranean. Instead, Britain profited by yet another route to the Far East.

It may be thought that in this modern world, with all the improvements in transport and communications which have characterised the last hundred years, position would be of little importance to these islands. Such, however, is far from being the truth. An attempt has been made in Fig. 3 to show facts which can much more readily be appreciated by a glance at a globe. From the thickly populated industrialised countries of northern Europe to the corresponding area of urban development on the far side of the Atlantic, characterised by the northeastern United States and by the St Lawrence Basin of Canada, the shortest route (the Great Circle route) lies across the British Isles. Presuming that the proverbial crow really does take the shortest route, that sagacious bird bound either from New York or from Montreal for any one of some fifteen or sixteen capital cities in Europe would, of necessity, have to pass over the British Isles. Actually, all ocean traffic from the ports of the northern seaboard of continental Europe bound

for North America has to make a detour to escape the British Isles and passes down the English Channel. The vessels are not taken out of their way by dropping anchor for a short time at one of the ports on the south coast of England, for example Southampton.

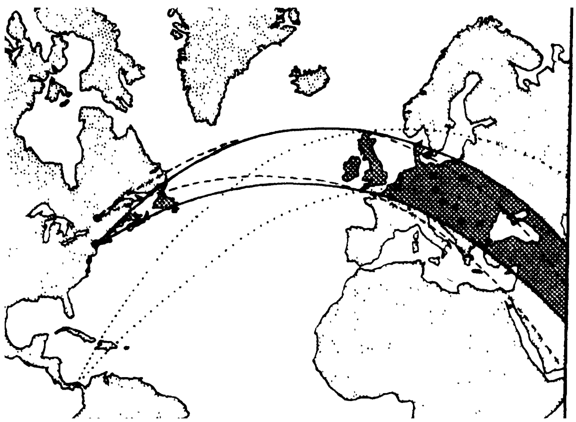


FIG. 3. Great circle routes from Europe to North America

Within the two dark lines are the shortest routes between New York and the capitals of European states marked by dots; in each case the shortest route passes through the British Isles. The pecked line shows the same relationship for Montreal; the dotted line for the Panama Canal.

The importance of constructing a Channel tunnel is once again before the public eye. The scheme is interesting geographically because if the tunnel were completed a British port, such as Liverpool, would almost automatically become the railhead of the whole European system—providing a new route for passengers and mails from Europe to America. However, where speed is important airways have replaced both seaways and railways. It is an interesting experiment to take a globe and a piece of string and to notice the shortest distance between Europe and various other parts of the world, and also to calculate the saving of distance—not to say the saving of time—which results by the utilisation of new routes. In any case they all serve to stress the importance of the position of Britain at present and the importance which its position is likely to maintain in the future. The modern development of trans-Atlantic air transport has already demonstrated this. Eastward bound it is not difficult to make Montreal or New York to London in one hop and from New York London may be bypassed en route to a continental airport. The westward flight, however, was often a battle against headwinds and convenient stops are afforded by Prestwick (Ayrshire) or Shannon (near Limerick), Goose Bay (Labrador) or Gander (Newfoundland). Not infrequently surprised passengers found themselves touching down in Iceland. In recent years however the in-

creasing range and speed of aircraft have to some extent altered the position. In 1956 Scandinavian Air Services (SAS) established a regular passenger service from Copenhagen to Tokyo via the North Pole as shown in Fig. 4. Canadian Pacific Airlines make the journey Vancouver to Amsterdam with only one stop. British Overseas Airways Corporation (BOAC) pioneered with jet-liners in 1952 doubling previous speeds of 320–480 kilometres (200–300 miles) per hour. The jumbo-jet, in service in the nineteen-seventies, ferries 500 passengers at over 960 kilometres (600 miles) per hour. One strategic result is that Europe and North America now have polar frontiers to guard. In 1958 for the first time more passengers crossed the Atlantic by air than by sea: each year since the air lead has increased.

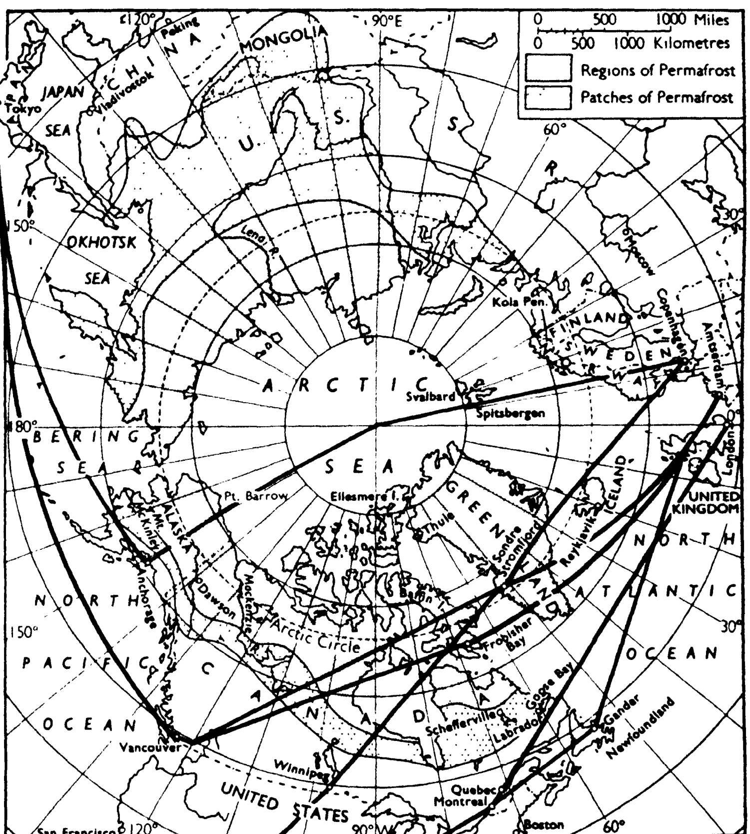



FIG. 4. Trans-Atlantic and trans-Polar air routes

The world relations of Britain reflect in many ways her world position. If, by virtue of situation, the British Isles belong to the Continent of Europe, it is still not too much to say that the British Isles do not really belong to

Europe. Viewed from the other side of the Atlantic, it seems obvious that Britain would form an essential unit in a United States of Europe or Western European Union. But the countries of continental Europe are more 'foreign' to the people of Britain than are countries overseas more distant but more closely related, such as the United States of America and, still more, the countries of the British Commonwealth. Some years ago Professor C. B. Fawcett carried out an interesting calculation in studying the direction of foreign mails from the British Isles. Eliminating business correspondence, the mail to America and our overseas dominions was overwhelmingly more important than that to the countries of continental Europe. Blood ties, linguistic ties, social ties and economic ties are with the new lands of the world. However, after six countries of the heart of Europe —West Germany, Italy, France, Belgium, Netherlands and Luxemburg— had linked themselves as the European Economic Community, popularly called the European Common Market, of 300 million people it was difficult for Britain to ignore certain advantages which might accrue from membership. Negotiations, opened in 1961, were protracted and many conflicting views emerged before the breakdown in February, 1963. In 1967 a further application for entry was unsuccessful.

The British Isles lie mainly within the quadrilateral formed by the two lines of longitude 0° and 10° West and the two lines of latitude 50° and 60° North. In latitude the position is roughly comparable with the almost uninhabitable lands of Labrador, to the northern part of British Columbia, and again to the almost uninhabitable lands of Sakhalin and the Kamschatka Peninsula of the coasts of Asia. The British Isles, indeed, enjoy a more favourable climate than any other land so far from the equator. To the north of the islands the sea way is open between the coasts of Iceland and of Norway to the Arctic Ocean, and a constant drift of warm water and of correspondingly warm air passes by these islands into that open channel. We have long been accustomed to refer to this drift of water as the Gulf Stream, and if purists prefer to call it the North Atlantic Drift it does not alter the fact of the significance of the phenomenon. More especially, of course, is the fact significant in winter, since the shores of the British Isles lie in the winter gulf of warmth. Apart from the advantages of world position, there are numerous advantages from the position of the British Isles more local in character. The existence of a broad Continental Shelf on which the warm waters drifting across the North Atlantic are piled up ensures not only the maximum benefit from these waters in the amelioration of climate, but it accentuates the movement of water by the tides. Thus our ports, always free from ice, are kept free from silt by the strong tidal scour, while the shallow seas on the Continental Shelf afford the richest fishing grounds in the world, where variety, caused by the constant movement and mixing of the waters, is the spice of life in the fish world. The English Channel, narrowing eastwards to the Strait of Dover, which is only twenty-one miles (under 34 kilometres) wide at the narrowest part, sepa-

rates the south of England from France. The North Sea lies between Britain and Holland, Germany, Denmark and Norway.[1] Whatever may be the opinion of travellers crossing the 'silver streak', these separating seas are a great advantage to the islands rather than the reverse. The part they played in saving Britain from invasion during the Second World War is too well known to need emphasis. But Britain is double-faced. The ports on her southern and eastern shores face the most important and most developed parts of northern Europe. The embouchure of the Thames is opposite that of Europe's most important river, the Rhine. On the other hand, Britain's west coast ports face the most developed parts of America. This is again symbolic of the intermediate position which Britain occupies, political, financial, and commercial, between America on the one hand and the countries of Europe on the other.

### Note

In citing statistics and statements relative to the British Isles the greatest care must be taken to note the area to which reference is made in each specific case. The island of Great Britain consists of three countries—Scotland in the north, Wales in a part of the west, and England occupying the remainder. England, Scotland and Wales have been joined under one monarch since 1603; but whilst England and Wales are usually considered together for many purposes, Scotland is distinct. Thus the Ministry of Agriculture, Fisheries and Food refers to England and Wales but not to Scotland. Statistics and details which are published by this and other Ministries refer, therefore, to England and Wales only. Since 1920 Ireland has been divided into Northern Ireland and the Irish Free State (now known as the Irish Republic or Eire). Northern Ireland has a parliament of its own, but is otherwise closely united to Great Britain. But the Republic of Ireland is an independent republic. Thus 'United Kingdom' used to mean the United Kingdom of Great Britain and Ireland, now it means the United Kingdom of Great Britain and Northern Ireland. The distinction is important when comparing pre-1914 with later statistics. For many purposes the Isle of Man, with a parliament (or House of Keys) of its own, is not part of the United Kingdom. Again, the laws of Great Britain do not apply to the Channel Islands unless such application is specifically laid down and approved by the islands. The table on p. 8 is given for reference purposes.

The table shows that the total area of the British Isles, including the Isle of Man and the Channel Isles, is 313 076 square kilometres (120 879 square miles) excluding inland water. This area is equivalent to about one twenty-fifth of continental United States. Out of this total the larger island of Great Britain is roughly 230 500 square kilometres (89 000 square miles)

1. Notice the shape of the North Sea. It is relatively narrow at its northern end, and the Shetland Islands lie almost halfway between the north of Scotland and the coast of Norway.

| | AREA (SQ. KM) | AREA (SQ. MILES) | POPULATION 1921 | POPULATION 1931 | POPULATION 1951 | POPULATION 1961 | POPULATION 1968[3] |
|---|---|---|---|---|---|---|---|
| England | 131 763 | 50 874 | 35 681 019 | 37 789 738 | 41 147 938 | 43 430 972 | 45 873 000 |
| Wales | 19 337 | 7 466 | 2 205 680 | 2 158 193 | 2 596 986 | 2 640 632 | 2 720 000 |
| Scotland | 78 748 | 30 405 | 4 882 497 | 4 842 554 | 5 095 969 | 5 178 490 | 5 187 000 |
| Isle of Man | 572 | 221 | 60 284 | 49 338 | 55 213 | 48 151 | 50 423[5] |
| Channel Islands | 194 | 75 | 90 230 | 93 061 | 157 983 | 104 378 | 104 378[6] |
| Northern Ireland | 13 564 | 5 237[1] | 1 256 000[3] | 1 243 000[3] | 1 369 579 | 1 423 127 | 1 502 000 |
| Republic of Ireland | 67 897 | 26 601[1] | 2 971 992[2] | 2 965 854[4] | 2 958 878 | 2 834 000[3] | 2 884 002[7] |

[1] Excluding water areas. [2] 1926. [3] Estimated. [4] 1936.
[5] 1965 census. [6] 1961 census. [7] 1966 census.

with over 53 million people, the smaller island 82 900 square kilometres (32 000 square miles) with about 4.4 million people. The population of the United Kingdom of Great Britain and Northern Ireland with the Isle of Man and the Channel Islands passed the 50 million mark about 1950 – on its total area of 244 179 square kilometres (94 278 square miles). The census population of the whole United Kingdom in 1966 was 53 788 000. The figures of area given on p. 151 are smaller because inland water is excluded.

The Registrar-General's mid-year estimates for 1968 gave the population of the United Kingdom as 55 282 500.

# 2
# The physiographic evolution of the British Isles

The present surface features of the British Isles, as well as their relationship to the features of the neighbouring parts of the Continent of Europe, are the reflection of the long and complicated geological history of the area. Geology has been described as geographical evolution, but, conversely, the existing physical geography of a country is the result of its geological evolution from the dawn of geological time to the present day.

The geologist has divided geological time into at least five great eras and each of those eras into a number of periods. On broad lines the rocks which were laid down in each of those periods can be made to tell the story of the earth's history. Each period was characterised by its own sets of animals and plants, the remains of which have been entombed in the rocks and can be found today as fossils. Nor are these episodes in the past history of the earth merely of academic interest. Whether it be in the search for minerals of economic importance or the study of the disposition of these deposits when found in its relation to economic costs of mining; whether it be the study of the rocks of the earth's crust in relationship to the soils which they afford or in relationship to construction on the earth's surface, the studies of the geologist are of fundamental importance. No excuse, therefore, need be made for considering in this chapter the physiographic evolution of the British Isles, by attempting to trace the history of these islands from the earliest times to the present.

The five eras—the Pre-Cambrian (in the rocks of which earliest era no remains of life are commonly found), Primary or Paleozoic, Secondary or Mesozoic, Tertiary or Kainozoic (Cenozoic), and, finally, the Quaternary or Modern Period—are the great divisions which the geologist has made in the geological time scale. Subdivisions of these are shown in the diagram overleaf. Further subdivisions are of course made, but those listed are of fundamental importance in that they are in common use for numerous purposes.

Little is known of the geography of Pre-Cambrian times. The rocks of this great era found in the British Isles fall into three main groups:

(*a*) Crystalline or metamorphic rocks, the descriptive name 'metamorphic' indicating that they have changed their form: as the result of heat and pressure they have become recrystallised. They are hard, resistant to

| ERA | PERIODS OR systems | EARTH MOVEMENTS | IGNEOUS ACTIVITY | CHARACTERS OF ROCKS AND SOILS |
|---|---|---|---|---|
| QUATERNARY | RECENT<br>PLEISTOCENE AND ICE AGE | | | Drift, alluvium and gravel deposits |
| TERTIARY OR CENOZOIC | PLIOCENE | | W Scotland & Antrim Volcanics Mourne Mts Granite | Crags of East Anglia and some gravels. |
| | MIOCENE | Alpine Earth Movements | | Almost absent in Britain |
| | OLIGOCENE | | | Sands and clays, where mixed giving good loams; clays give heavy soils, sands very light (London and Hampshire Basins). |
| | EOCENE | | | |
| SECONDARY OR MESOZOIC | CRETACEOUS | | | Great mass of chalk forms the upper part; sands, sandstones and clays in lower part |
| | JURASSIC: OOLITES, LIAS | | | Alternations of sandstone or limestone giving cuestas and clays (giving vales) |
| | RHAETIC | | | |
| | TRIASSIC | | | Upper Keuper rocks give wet red soil of Midlands Lower Bunter sandstone, poorer sandy soil. |
| PRIMARY OR PALEOZOIC | PERMIAN | Armorican Earth Movements | Cornish Leinster Granites &c | Magnesian limestone and red marl giving fair to good red soil |
| | CARBONIFEROUS: COAL MEASURES | | | Sandstones and shales often very fair soil |
| | CARBONIFEROUS: MILLSTONE GRIT | | | Grit or sandstone, uplands, poor soil |
| | CARBONIFEROUS: CARBONIFEROUS LIMESTONE | | | Limestone and sandstone forming uplands except in Ireland |
| | DEVONIAN | Caledonian Earth Movements | Manx Volcanic Rocks, Newer Scottish Granites | Upper part of Old Red Marl often fertile red soil Lower part of Old Red Sandstones, flaggy, poor soil |
| | SILURIAN | | | Hard old sedimentary rocks, slates, grit, sandstones, etc Poor siliceous soils Igneous rocks stand out as hill masses. |
| | ORDOVICIAN | | Lavas &c Wales & Lake District | |
| | CAMBRIAN | | | |
| PRE-CAMBRIAN | | Charnian & Other Movements | Older Scottish Granites | Hard metamorphic and crystalline rocks. Poor siliceous soil. Upper part with sandstones |

Table of geological time periods

weathering, and, except where the continuous action of the agents of denudation through untold ages has slowly but surely worn them down almost to sea-level, they tend to form hill masses. It used to be thought that these hard crystalline rocks represented the original crust of the earth. But in one area after another the Pre-Cambrian crystalline rocks have been shown to represent sediments deposited on a solid crust of an already existing world and which were later much altered.

(*b*) Ancient volcanic, and other igneous rocks, of the same period.

(*c*) Sedimentary rocks, such as sandstones and shales, which have suffered less alteration but which are nevertheless older than the most ancient of the rocks which have yielded fossils.

It seems clear that in Pre-Cambrian times there were at least several great periods of folding or earth movement and volcanic activity, and that the earliest rocks were highly folded and ridged up into great mountain chains, before the deposition of those sandstones and other sediments mentioned under (*c*). Thus it is possible, for example in the northwest Highlands of Scotland, to see the way in which the coarse red sandstones known as the Torridonian and which are themselves Pre-Cambrian, rest in hollows amongst the still older mountains of Pre-Cambrian times. One system of folding developed in some of the small ancient blocks of the Midlands of England, notably in Charnwood Forest, has produced northwest to southeast or 'Charnian' folds.

During the first three periods of the Paleozoic era, that is during the Cambrian, the Ordovician, and the Silurian, the earth was inhabited almost exclusively by lowly creatures which had not yet attained the dignity of possessing a backbone. It is possible that during most of these periods a great land mass lay to the northwest of Scotland, and that a broad sea trough ran across the British Isles. At certain times islands occupied part of Britain and, particularly during the Ordovician, volcanic activity was rife. Some of the volcanoes were submarine and poured out their lavas on the sea floor; others were volcanoes of an explosive type which threw out huge quantities of ashes. Thus we find that the deposits of the Cambrian, the Ordovician, and the Silurian periods are, for the most part, marine sediments, originally clays, silts, sands and coarser deposits; but interbedded with these are found the lavas of contemporary volcanoes and beds of ashes. Intruded amongst the sediments are other masses which came up in a molten condition from the lower layers of the earth's crust and which solidified before reaching the surface. Most of the old sediments have become hardened. The clays have become hard shales and slates, the silts and sands have become sandstones, quartzites and other hard rocks, so that again the sediments of these three periods tend to form hill and mountain masses, and to occur in what will later be described as the Highland Zone of the British Isles. The various igneous rocks are even more resistant to the agents of weathering than are the sediments, and many of

the highest mountains of the British Isles are formed of the ancient lavas which were extruded at this time, familiar examples being Snowdon and Cader Idris in North Wales.

Towards the close of Silurian times occurred one of the great periods of mountain building which from time to time have played an enormous part in the determination of the present surface features of the earth. It was during this great period of earth movements that the Highlands of Scotland

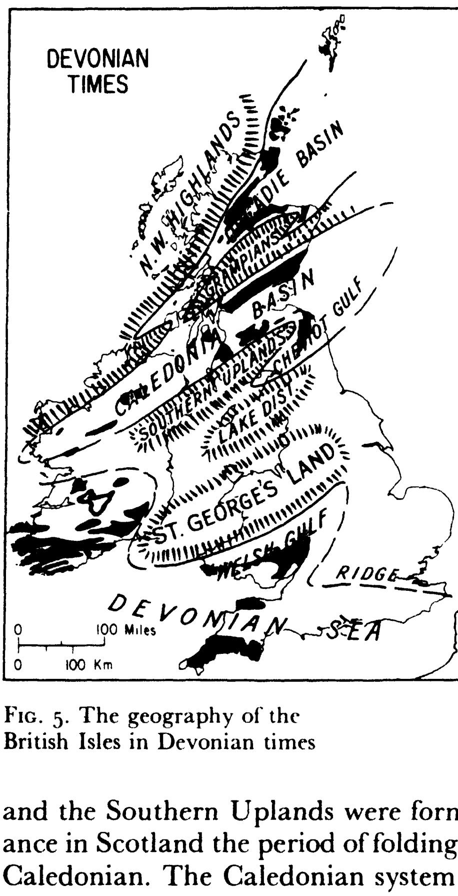



FIG. 5. The geography of the British Isles in Devonian times

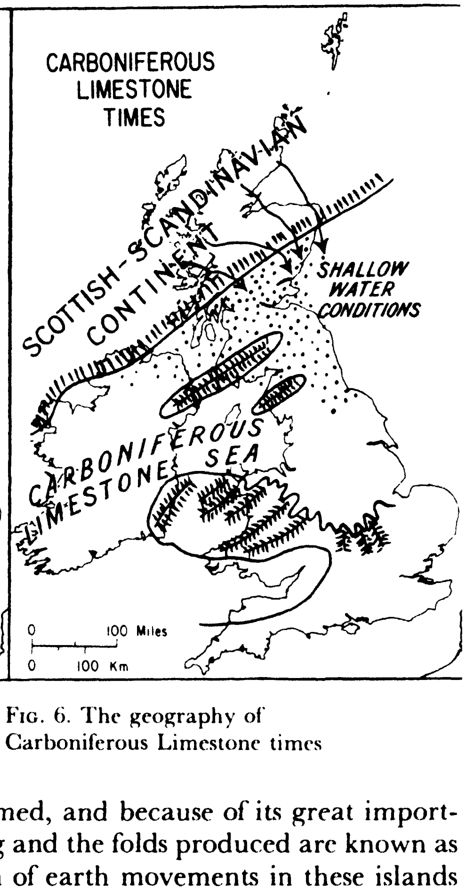



FIG. 6. The geography of Carboniferous Limestone times

and the Southern Uplands were formed, and because of its great importance in Scotland the period of folding and the folds produced are known as Caledonian. The Caledonian system of earth movements in these islands resulted, for the most part, in the formation of a series of mountain chains which ran from southwest to northeast. So characteristic is this direction for the mountains that it is known commonly as the Caledonian trend. This dominant trend is very clear in the mountains of the Highlands of Scotland, in the Southern Uplands and their continuation into Ireland, in the mountains of north Wales, and to a less extent is apparent, but nevertheless important, in the Lake District. The Caledonian earth movements commenced towards the end of the Silurian and they were prolonged into the succeeding Devonian period, and the sea-trough of Silurian times disappeared. Most of the British Isles became a land mass, but between the

great ridges of mountains were deep mountain-girt valleys or basins. In these torrential streams from the recently formed mountains deposited great thicknesses of coarse conglomerates and sandstones. These are the deposits which we know under the famous name of Old Red Sandstone, and it is remarkable that the Old Red Sandstone deposits often occupy hollows even at the present day, particularly in Scotland. It was only over the south of England that there existed contemporaneously a sea, and in this sea were deposited the Devonian rocks—muds, sands and silts with local limestones—which form the Devonian Series in Devon, Cornwall and the adjoining parts of Somerset and are found also over areas in South Wales. In South Wales and the Welsh border they mingle with deposits of Old Red Sandstone type. It may be that the characteristically red colour of the Old Red Sandstone reflects desert conditions in the neighbouring mountains. Not unnaturally the few fossils which are found in the Old Red Sandstone are of fish, the first backboned creatures (which lived in the transient lakes of the great mountain valleys) and primitive land plants. The enormous thickness of many of the Old Red Sandstone deposits testifies to the rapidity with which the Caledonian mountains were worn down by the agents of atmospheric weathering. Towards the close of the Devonian period the mountains were already mere remnants of their former selves and they yielded only fine sand and red mud or marl. The beginning of the succeeding period—the Carboniferous—was marked by a great invasion by the sea of practically the whole area. The sea flowed into the pre-existing mountain basins, except in the north where there still existed the great continental mass, the remnants of which now form the Highlands of Scotland. Over England and Wales and much of Ireland the mountains had been worn down to such an extent that they yielded but little sediment. In the waters of the Carboniferous sea there flourished a wealth of corals and other organisms which are favoured by clear water; and so the deposits laid down were limestone (Carboniferous Limestone). The name once used for Carboniferous Limestone was Mountain Limestone indicating the association of this limestone with mountain or upland areas, particularly of the Pennines. But the great continent which extended from Scotland to Scandinavia yielded sediments which prevented the extensive growth of clearwater organisms in what is now the north of England and the Midland Valley of Scotland. So here one does not see the great thicknesses of Carboniferous Limestone found farther south; instead there are thin beds of limestone in a mass of sandstones and shales. These sandstones and shales represent material brought down by rivers draining from the northern continent. In the middle of the Carboniferous period a huge river gradually began to overwhelm the British area and to spread its great deposits of sand on top of the limestone which had been just formed. We have really in Britain the formation of an enormous delta, and because of the former use of the sandstone of these deltaic deposits as millstones the deposits are known as the Millstone Grit. The Millstone Grit delta extended from Scot-

land right across the Midlands of England as far as an island, or perhaps a peninsula from an European mass, known as St George's Land, which extended from central Wales through the heart of England.

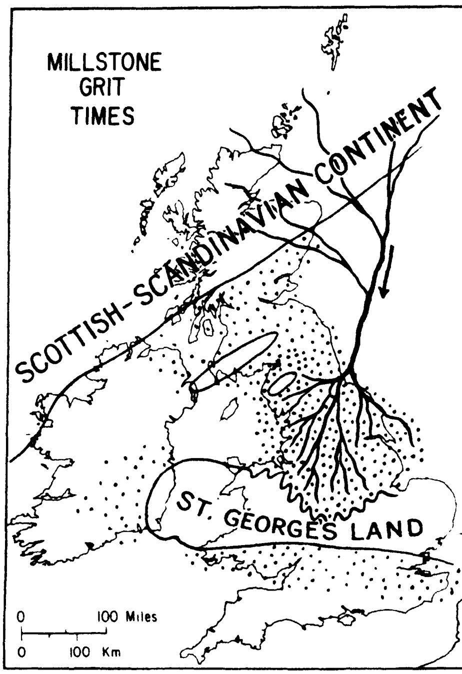



FIG. 7. The great river delta of Millstone Grit times

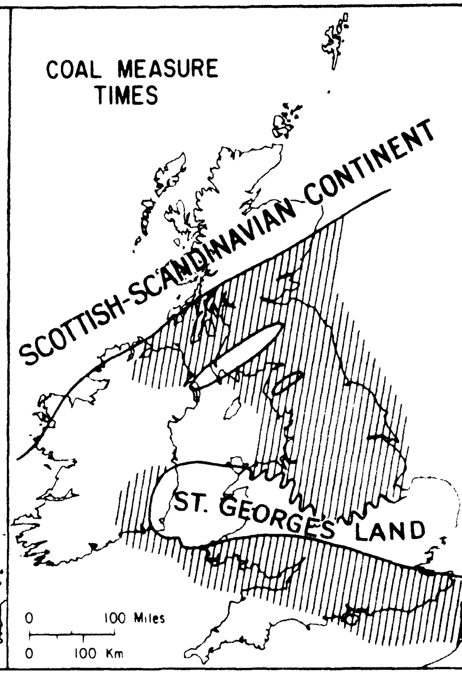



FIG. 8. The geography of Coal Measure times. The shaded portion shows the area where the coal forests flourished

The great delta which was formed during Millstone Grit times prepared the way for the very widespread growth of swamp forests in the succeeding period of the Coal Measures. The forests of tree ferns and allied plants, the remains of which form the coal seams of the present day, flourished in swampy tracts which have been compared by some to the mangrove swamps of the tropics of today, and by others to freshwater swamp forests such as the Everglades of the United States in Florida. Conditions suitable for the growth of such forests were to be found along the margins of the Scottish land mass as early as Carboniferous Limestone or Millstone Grit times, but it was not until the deposition of the great Millstone Grit delta that conditions became suitable over the huge area between the Scottish land mass, where now one finds the Scottish Highlands, and that land that existed across the middle of Britain and to which the name of St George's Land has been given. There is little doubt that the Coal Measure forests grew over continuous areas from what is now the Scottish border to the

Midlands of England, and right across the area where now the Pennine Upland is found. To the south of St George's Land, in what is now South Wales, the Forest of Dean, the Bristol area, and right across southern England through east Kent into northern France and Belgium there were similar conditions equally suitable for the growth of forests. It is clear that at intervals the forests were overwhelmed, and indeed entombed, by masses of sand and mud which were brought down by rivers similar in character to those which deposited the Millstone Grit. At other times the slight changes in surface level caused an inrush of the sea, and so in parts of the British Coal Measures there are found thin marine bands. Under most of the British coal seams there are found beds of clay, often with traces of roots, and it would seem that these Coal Measure swamp forests grew in a dark muddy slime, not very different from that in which mangrove swamps grow at the present day. Sometimes this layer of clay underneath the coal seams is of value in that it furnishes fireclay. Occasionally it has become silicified and is important as 'ganister'. There is little doubt that the land masses of Coal Measure times had been worn down greatly, in fact almost to sea-level, and towards the close of the period there is evidence that desert conditions prevailed on the neighbouring land masses.

The close of Coal Measure times is marked in many parts of the world by a great series of mountain-building movements, frequently known as the Carbo-Permian earth movements, since the succeeding period is that of the Permian. In the British Isles these movements resulted in four sets of folds:

1. In the north and northwest of the islands the Carbo-Permian movements resulted in the accentuation of pre-existing folds which had been formed by the Caledonian earth movements.
2. In such areas as central Wales new folds were formed, broadly speaking parallel to the pre-existing Caledonian folds, that is with a trend from southwest to northeast. The great anticline of the Vale of Towy in central Wales is a good example.
3. The most characteristic folds, however, of the Carbo-Permian earth movements are those which have an east and west trend and which are best exemplified in the folding of South Wales and the formation of the South Wales coal basin. The highly complex folds with their axes roughly from east to west which are found in Devon and Cornwall are also of this period, and there they were accompanied by the intrusion of vast masses of granite. On the other side of the Channel the east–west folds of Brittany are of the same age. Brittany, or 'Armorica', shows the folds of the Carbo-Permian earth movements so well that they are known as the Armorican earth movements or, alternately, as the Hercynian, from the Harz mountains of Germany.
4. In other parts of England north–south folds characterise this period, and there is little doubt that the general uplift of the Pennines which resulted

in the separation of the Coal Measures into an eastern and a western series of basins originated at this time. Another north–south structure of Carbo-Permian age is the line of the Malvern Hills, which now forms the eastern limit of the massif of ancient rocks making up Wales.

As a result of these great Armorican earth movements, at the beginning of Permian times Britain was occupied by an important series of mountains, between which there were deep mountain-girt desert basins—and naturally the earliest Permian deposits are usually coarse breccias which are of the nature of screes from the newly formed mountains. Beds of coarse conglomerate and boulders, laid down by torrential streams, are also found. There is one very well known Permian basin containing rocks of this character, and that is the one which occurs in the southwest, over the eastern parts of what is now the county of Devon and the neighbouring parts of Somerset. A great sea, or possibly salt water lake, comparable to the Caspian at the present day, covered much of Germany. It may, or may not, have been continuous with the main ocean which lay to the south of Europe. This German sea stretched across the North Sea and its western shores were to be found in northern England. After the early sandy deposits the well known Magnesian Limestone was laid down in the north of England and is found in its best development in Durham and Yorkshire. The waters of the Magnesian Sea seem to have found their way round the southern edge and perhaps across the north of the newly formed Pennines, and attenuated remnants of the Magnesian Limestone are therefore found on the western side of the Pennines. There is little doubt that the land surrounding these areas was under desertlike conditions; most of the sandstones and marls of Permian age are red; many of them contain grains of sand worn smooth by wind action. The Permian deposits thus form the lower part of what the older geologists described as the New Red Sandstone. This name was not ill-chosen, since the conditions of deposition of the beds must have closely resembled those of the Old Red Sandstone.

Although the Permian is the youngest of the Primary or Paleozoic systems, there is little break in England between the Permian deposits and those of the succeeding Trias, the oldest of the Secondary or Mesozoic. The Trias takes its name from the threefold division which is possible in the rocks of this series in most parts of northern Europe into Bunter, Muschelkalk and Keuper. The coarse red sandstones and pebble beds of the Bunter period were laid down in roughly the same areas as the Permian deposits. Like the Magnesian Limestone, the Muschelkalk of Germany and much of Europe was laid down in an inland sea, doubtless a saltwater sea, which, like the Magnesian Limestone sea, stretched from Germany across towards England. The Muschelkalk itself as a limestone is, however, absent from England. Here the Bunter Sandstones are succeeded by a considerable thickness of red sandstones and marls (Keuper) which were clearly laid down in a shallow basin surrounded by desert country. At intervals this basin was dry, for one finds deposits of salt (of considerable economic

importance) and gypsum, representing salts that were deposited when the shallow basins dried up. Many of the deposits are ripple-marked; others show pittings due to rain storms on the scarcely dry mud. This was an age when giant reptiles first began to be important and the remains of some of them are entombed in the Triassic deposits. Some of the masses of older rocks—the remnants of the Carbo-Permian Mountains—stood up as islands in the Triassic salt lake or sea of the Midlands of England. Examples are preserved to us today in the Wrekin, the Lickey Hills, the Mendips and the hills of Charnwood Forest, so that one finds the red Keuper deposits wrapping round the margins of the ancient rocks. It is the red Keuper Sandstones and Marls together with glacial drifts largely derived there-

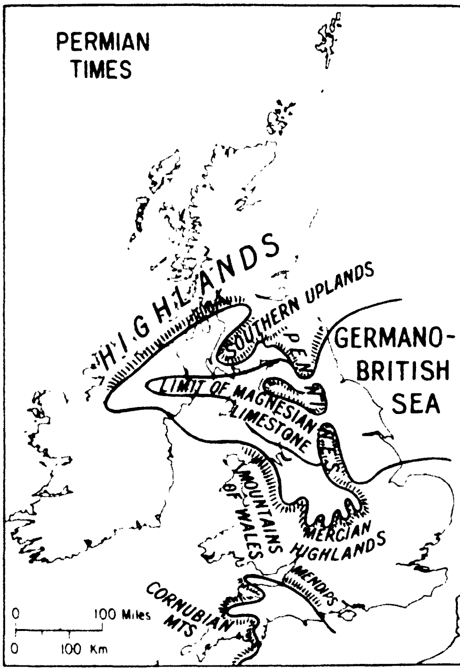



Fig. 9. The seas and salt lakes of Permian times after the Carbo-Permian earth-building movements

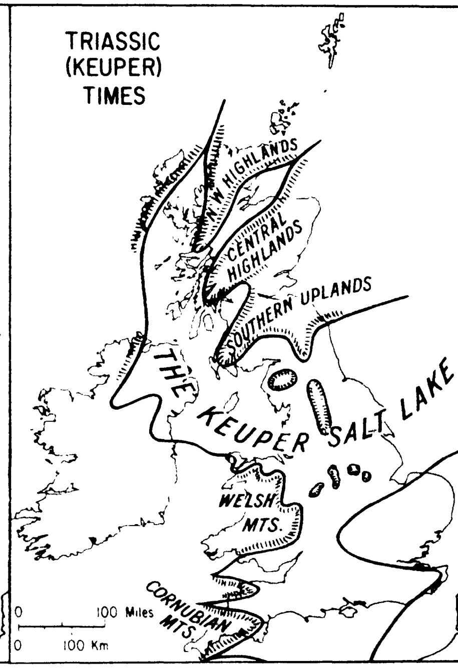



Fig. 10. The geography of Keuper times

from which are in the main responsible for the red soils so common in the Midlands of England. The Marls give rise to a soil which is rich, though tending to be waterlogged, but fertile for agricultural purposes if well drained.

The next phase in the physiographic evolution of the British Isles began with the irruption of a sea into the old Triassic basins. Many of the creatures living in the Triassic Sea, such as fishes, were killed off by this sudden incursion of marine waters, whilst organisms which were brought in by the

marine waters found themselves unable to survive under the new conditions. Hence it is not surprising to find the earliest deposits of the Rhaetic, as the succeeding period is called, consist frequently of 'bone beds', built up entirely of the remains of fishes and reptiles. But in time the sea covered the whole area of the Triassic basins and even overstepped them on to the neighbouring land masses. By this time the land masses were worn down so that the material they yielded was more often of the nature of fine sands and muds, rather than coarse deposits. Conditions favoured the development of certain types of limestone. Deposits attributed to the Rhaetic on the Continent of Europe often attain a great thickness but in Britain the whole period is represented by only a thin series of deposits. The important Jurassic period which succeeds it is represented by a great series of beds which can be divided into three great groups. The Lower Jurassic deposits were the Liassic deposits and are mainly of clay or mud, argillaceous limestones, and occasional sands. In the water of the Jurassic seas enormous numbers of ammonites flourished, and these are really the dominant fossils of the period. Although there were no great earth-building movements during the Jurassic period, there were doubtless small folding movements; and the deposits of the Middle Jurassic comprise limestones, sandstones, and clays laid down in the tranquil waters of basins more or less cut off from one another.[1] Where the waters were clear and free from sediment the conditions were particularly suitable for the accumulation of the Oolitic Limestones, and the famous freestones of Bath belong to this period. In the Upper Jurassic, on the other hand, clays and sands again predominate over the calcareous deposits though the famous Portland stone is of this age. The difference between the soft and easily eroded clays and the harder beds by which they are separated has been a factor of the utmost importance in determining the relief of the present day southeast of England. Towards the close of the Jurassic period the sea retreated to the northeast, while the extreme southeast of England was covered by a great lake, the Wealden Lake, which stretched across what is now the English Channel into France. In this Wealden Lake were laid down deposits of sand and clay, such as the Hastings Sand and the succeeding Weald Clay found at the present day in the heart of the Weald of Kent, Surrey and Sussex. Around this Wealden Lake lived enormous numbers of giant reptiles such as iguanodons, whose remains are found in the lake deposits. In the seas which still covered the northeast of England were deposited various beds, including the Speeton Clay of Yorkshire.

Just as the Triassic Lake basins were later invaded by Rhaetic seas, so the Wealden Lake basin and the northern marine area were afterwards invaded by the sea of the earlier Cretaceous period. Naturally the earlier deposits were sands and muds, but there had been no extensive earth-

1. This accounts for the discontinuous character of the scarps formed by the harder beds (see pp. 47–8).

building movements affecting Britain since Carbo-Permian times, so that the lands surrounding the invading Cretaceous seas were low and yielded but little sediment. There is evidence that on these lands a desert type of climate prevailed. After the formation of the Greensand and Gault Clay deposits the waters of the Cretaceous seas became deeper and were extremely clear. The conditions thus favoured the deposition of one of the most famous of all the deposits found in the British Isles, that remarkably pure white limestone which we know as Chalk. It used to be thought that the Chalk was laid down in deep water under conditions comparable to those prevailing in the open Atlantic Ocean where white 'oozes' are being formed at the present day, but it is now believed that the Chalk sea was

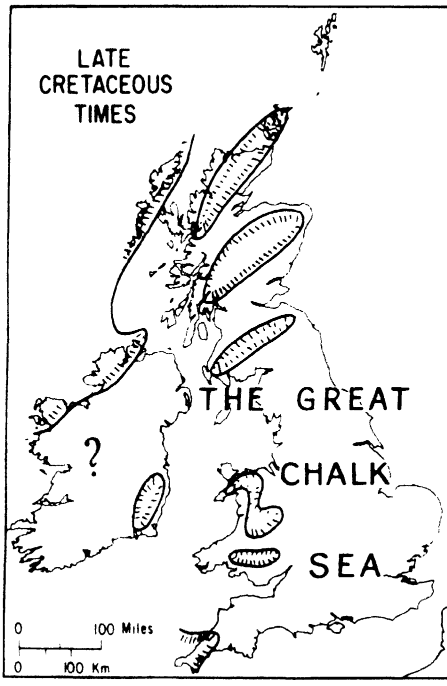



FIG. 11. Map showing the area *probably* covered by the Chalk Sea

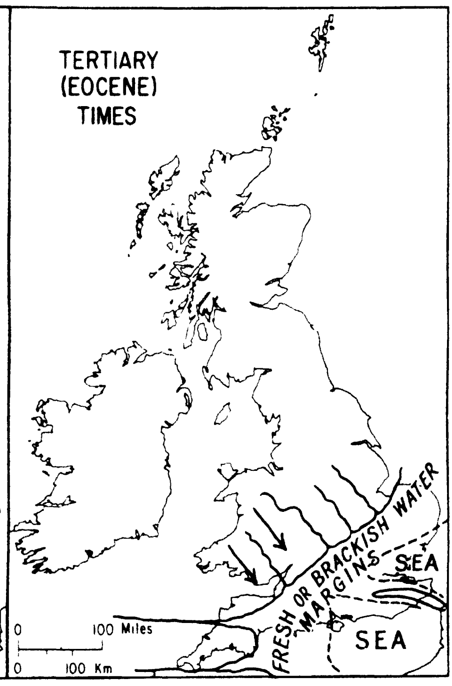



FIG. 12. The geography of Eocene times

not necessarily a deep sea, but merely one in which the water was clear owing to the absence of sediment brought from the land. The Chalk itself consists partly of the remains of multitudes of tiny organisms, particularly of foraminifera. It is partly a precipitate of lime. The exact limits of the Chalk sea in Britain are not easy to determine. It is believed by many that the peneplanation or the smoothing of the mountains of Wales, and possibly even of parts of the Highlands of Scotland, is due to the action of the waves of the Chalk sea.

The Cretaceous is the youngest of the periods of the great Mesozoic or

Secondary era. Although in Britain there is comparatively little discordance between the bedding-planes of the Chalk and of the succeeding deposits there is a great change of character between the two. There was actually a considerable lapse of geological time between the deposition of the highest Chalk and the succeeding beds. The earliest of the Tertiary deposits in Britain are the Eocene, and with this period Britain began to assume some of the relief features which are so familiar at the present day. Most of Britain seems to have risen so as to form a great land mass and only the southeast of the country was covered by a sea. Into this sea there emptied one or more great rivers coming from the west from a continental mass which is now beneath the waves of the Atlantic Ocean. The rivers laid down sands and other deposits of predominantly continental origin in the western parts of what we call the Hampshire and London Basins, while towards the east of these same basins there were being deposited clays or muds containing marine fossils. There is on the whole an alternating succession of deposits of marine and continental origin which marks the various backward and forward movements of the marine waters of the Eocene sea.[1] The same sea covered the Paris Basin in the northern part of France as well as considerable tracts in Belgium and Holland. It was during the Eocene period that there occurred some of the earlier earth tremors which were gradually to increase in strength and to culminate in those earth-building movements which were the most important of all in determining the present physiography of Europe—the Alpine earth movements. It seems likely that the Wealden dome in southeastern England began to rise during the Eocene period.

The Oligocene period, which succeeds the Eocene, has left but little trace in Britain. If there were Oligocene deposits laid down in the London Basin they have been removed by denudation and Oligocene deposits are almost restricted in this country to the Hampshire Basin. Towards the close of the Oligocene and during the succeeding Miocene period the great Alpine storm broke. This great period of earth-building movements formed the Alps, the Carpathians and many of the other great mountain chains of the world. The British Isles were comparatively little affected, since earlier folding movements had exerted their full influence in the north and the northwest of the country and resulted in the formation there of great stable blocks too rigid to be further folded by the earth-building movements so paramount in central Europe; they were at the same time too distant from the main seat of the Alpine storms. It is to be expected that the southern parts of England would be the areas most affected by the Alpine movements; that is actually the case. The folds, for example, which run across the Isle of Purbeck and the Isle of Wight are of this age. The main folding of the Weald is also of the same date. Although the ancient rocks of the north

1. Economically this is of the utmost importance because of the variety of soils and consequent land utilisation which result.

of the British Isles were not folded they were rent and torn, and through some of the fractures burst enormous flows of molten rock giving rise to the lava plateaus of Antrim in Northern Ireland and of many parts of western Scotland, whilst some of the great granitic intrusions, such as the Mourne Mountains in Northern Ireland, some in Scotland, and Lundy Island belong to the same period. The succeeding Pliocene period saw Britain taking on very much the form that it has at the present day. The Pliocene sea lingered in what is now the London Basin and later retreated farther north to occupy the position of what is now the North Sea, so that Pliocene deposits in this country are restricted, broadly speaking, to the London Basin and to East Anglia. More important than the deposits left behind was the work of Pliocene seas, in cutting those flattened surfaces, bevelling many of our hills especially in southern England. It is only in recent years that the geological history of the times has been worked out from this fragmentary evidence.

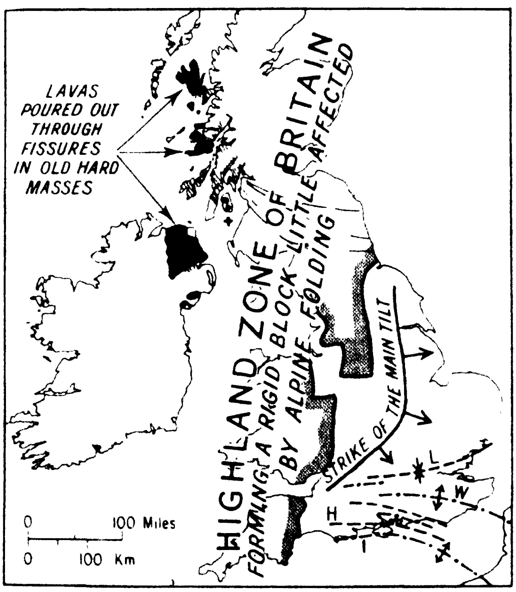



FIG. 13. Map of the British Isles showing the effects of the Alpine earth movements. The arrows show the dips of the rocks. The fine black lines in the north of England and in Scotland are dykes of igneous rock of the same age filling cracks

There was still to come, however, an episode in the geological history of these islands which has left its mark in nearly all places: and that was the Pleistocene Ice Age. At least three times during the Glacial Period the greater part of the British Isles was covered with ice sheets. Some of these were of local origin and had their centres in such upland areas as the High-

lands of Scotland, the Southern Uplands or the mountains of Ireland, whilst other parts of the British Isles, particularly the east, were affected by the enormous ice sheet which crossed the North Sea from the main centre of the Scandinavian mountains. The southern limit of the ice sheets in Britain ran roughly along the present day line of the Thames, so that Britain south of the Thames and of the Bristol Channel was not actually covered by the ice sheets, though it must have been subjected, like the presentday Arctic regions, to tundra conditions, with the ground permanently frozen to a considerable depth.

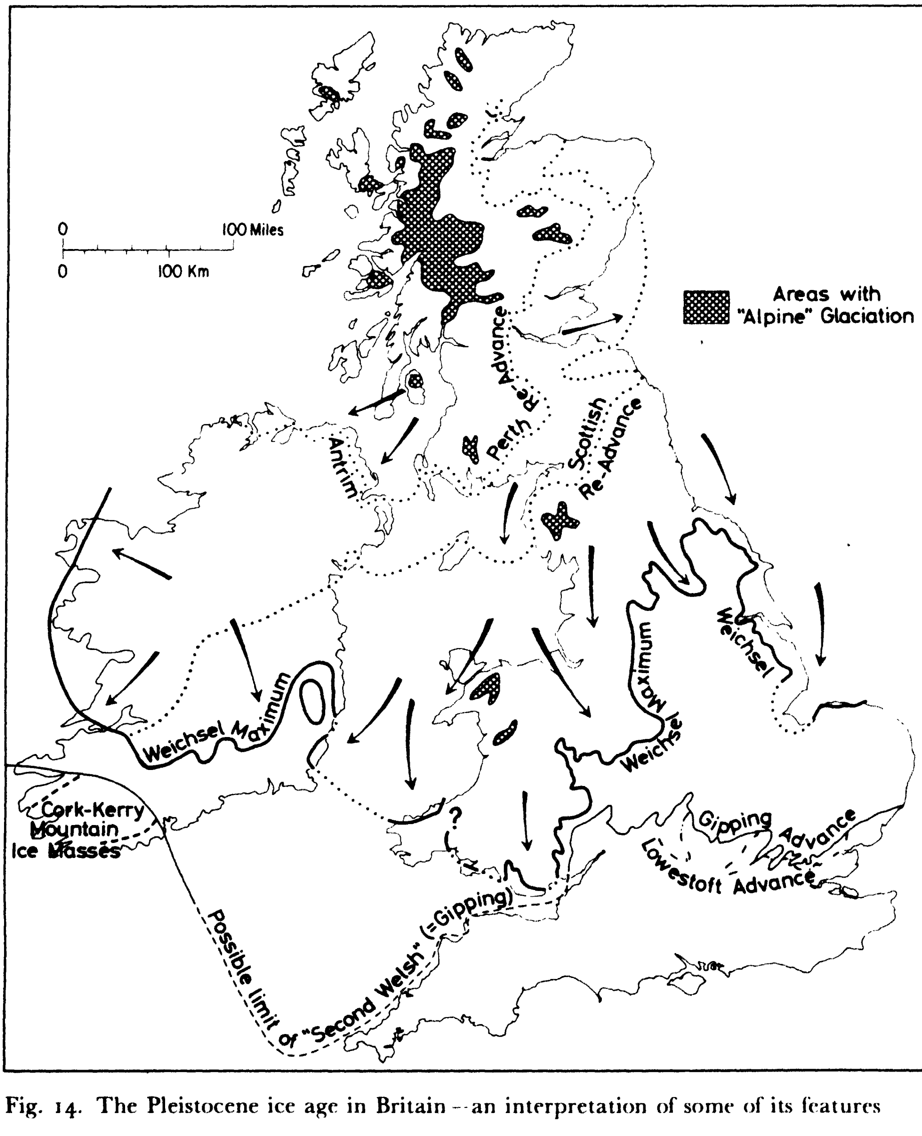



Fig. 14. The Pleistocene ice age in Britain -- an interpretation of some of its features

Of the four or perhaps five ice advances that are recognisable in the Alpine regions of Europe, only the last three are known to have affected the British Isles. During the first of these cold periods, known in the Alps as the Mindel, in northern Europe as the Elster, and in England generally as the Lowestoft, the ice front penetrated as far south as Oxfordshire and the lower Thames valley. During the succeeding warmer or interglacial period (called in England the Hoxne interglacial, from a locality in East Anglia where its deposits have been recognised) the ice may well have left the country entirely. But it advanced again during the period known in the Alps as Riss, in northern Europe as Saale, and in England as Gipping (another East Anglian locality), reaching roughly the same southerly limits as before, except for a probable southerly excursion across the Bristol Channel to North Devon, the Cornish coast and the Scilly Isles. After a further warm interglacial period (known in Europe as the Eemian and in England as Ipswichian) the last re-advance is known as the Würm (in the Alps) or Weichsel (in northern Europe and in England, though other more local names such as Smestow—a valley near Wolverhampton—have also been given to it). The Weichsel ice covered most of Wales, and the Irish Sea ice-sheet sent a broad tongue across the Cheshire–Shropshire plain into the West Midlands; but in northern England the middle and southern Pennines were ice-free, though another broad ice tongue stretched down the Vale of York, and a further tongue impinged on the east coast as far south as north Norfolk. Another Irish Sea ice stream just touched the Pembrokeshire and Wexford coasts, whilst over Ireland itself the southern limit extended roughly from Dublin via Tipperary to the mouth of the Shannon, with an ice cap on the mountains of Cork and Kerry.

Naturally enough, except in Midland and eastern England which were not overrun by the Weichsel ice sheets, far more is known about the Weichsel advance and retreat than about the earlier ones, the evidence of which has been largely obliterated; and various stages in the retreat of the Weichsel glaciers are recognisable on the ground (see Fig. 14). During these later stages, too, the higher mountains must have risen above the general ice level, so that they were subjected to frost-shattering, with the formation of corries and small valley glaciers of alpine type that have given character to the landscape, as in Snowdonia, the Lake District and many parts of the Scottish Highlands.

The Ice Age is of enormous importance in the physiography of the British Isles, because the ice sheets and glaciers moulded the surface of the country and left behind them various superficial deposits which are frequently of much greater importance in determining the character of surface utilisation than are the underlying solid deposits to which the geologist pays greater attention. Thus the ordinary geological map of the British Isles is really of comparatively little use to the geographer in his attempt to interpret the effect of soil on human activities and as a factor in the human environment. It is of utmost importance that he should consider what the geologist calls

2

## *Chronology of the Great Ice Age*

| | STAGES | NOMENCLATURE | HUMAN REMAINS AND CULTURES (mainly EUROPE) | IMPORTANT EVENTS AND DEPOSITS IN BRITAIN |
|---|---|---|---|---|
| UPPER PLEISTOCENE | Last glaciation | WEICHSEL (Wurm) (Smestow) | Cresswell Cave man<br>*Homo Sapiens*<br>Neanderthal man | Corrie glaciers in Highland Britain<br>York moraine<br>Lower terraces of Avon, Severn, Thames, Trent<br>Hessle and Hunstanton till |
| | Last interglacial | EEM<br>Ipswich | First Mousterian implements<br>Levallois techniques | Kidderminster terrace Severn |
| | Penultimate glaciation | SAALE<br>Riss<br>(Gipping | | Taplow Terrace (Thames)<br>Coombe Rock (glacial sludge) in south<br>Chalky Boulder Clay in Eastern England<br>'Early Scottish' glaciation and 'Second Welsh' drift |
| MIDDLE PLEISTOCENE | Penultimate interglacial | HOLSTEIN<br>Hoxne | Swanscombe man | Boyn Hill terrace (Thames)<br>Hoxne deposits (E. Anglia) |
| | Ante-penultimate glaciation | ELSTER<br>Mindel<br>Lowestoft | First Acheulian implements<br>Heidelberg (Mauer) man<br>Vertesszollos man<br>First Clactonian tools<br>Abbevillian implements | Plateau gravel (Thames and Chilterns)<br>'Pennine' and 'First Welsh' drift<br>Lowestoft till<br>Cromer till |
| | First interglacial | Cromer | | Cromer Forest Bed |
| LOWER PLEISTOCENE (upper part of) | Early glaciation | Gunz (Danubian Europe only) / Preglacial in Britain | First tools in Europe | 120 m (400 ft) Pebble gravel (Thames) |

the 'drift' map, the map which shows not only the solid rocks underneath but the superficial deposits, many of which are directly or indirectly connected with the great Ice Age. In general it may be said that the great Ice Age had at least the following effects:

1. The ice removed much of the soil which must previously have been formed in the mountainous areas and has rendered huge tracts of the Highlands of Scotland, for example, almost devoid of soil and therefore comparatively useless for agricultural purposes. The older rocks are exposed at the surface and have been smoothed by ice action, and one sees in the rounded outlines of the relief of the Highlands some of the results of the work of ice. Tongues of ice scooped out pre-existing valleys and smoothed the sides and gave the characteristic U-shaped valleys, with sides almost devoid of soils, which one finds throughout the Highlands and, indeed, in many parts of northern England and Wales and of Ireland.

2. Over the low-lying areas glacial deposits were laid down. Some of these consist of coarse sands and even of boulders of morainic character. Elsewhere there are boulder clays—stiff clays full of boulders of various rocks. Or again, there are outwash fans of gravel and sand which were laid down by torrential waters caused by the melting of the glaciers. In the fourth

place, some of the finer glacial deposits were redistributed by wind, and while the climate of England seems to have been too humid for the formation of vast quantities of loess, which are found in regions where conditions south of the ice masses were drier, the brick-earth of England has many of the characters of loess, and is really loess deposited under more humid conditions or under water. These brick-earths are essentially characteristic of the south of the country.

3. Then the glaciers profoundly altered the drainage of the British Isles and there are innumerable examples of pre-existing drainage which has been affected by the Ice Age. Many ice-dammed lakes were left during and after the retreat of the ice and today the fine sediments deposited in these glacial lakes afford some of our most fertile lands.

Since the retreat of the ice sheets from the British Isles there have been several fluctuations in level. Evidences of these fluctuations in level are found in the raised beaches which occur in many places along the coasts, whilst movements of the opposite character are evidenced by submerged forests. Then, again, one must always remember that there has been a progressive change from the extreme cold of the great Ice Age to the climatic conditions which are found at the present day, though the change may have been interrupted by cyclic fluctuations. The spread of the present vegetation into these islands must have been governed by the changing climatic conditions; doubtless, very considerable portions of the preglacial flora managed to persist in the south of the country and formed the nucleus for the reclothing of the British Isles.

The evolution of the rivers and drainage system of Britain will be separately considered; but it should be borne in mind here that there was a drainage system in existence prior to the formation of the ice sheets of the great Ice Age, that this earlier drainage system was profoundly affected by ice action, and that the present river system of these islands reflects in most cases the result of glacial interference.

# 3
# The physiography of the British Isles

In the last chapter, by considering the changes in the distribution of land and water over successive geological periods, we traced in bare outline the evolution of the physiography of these islands. In the present chapter we must analyse the physiography as it is at the present day. Leaving on one side for the moment the island of Ireland, the island of Great Britain is broadly divisible into two parts: a Highland Zone on the north and west, a Lowland Zone on the south and east. It is possible to suggest more than one line which may be used to separate these two divisions, but the most satisfactory seems to be that used in Fig. 15 and elsewhere in this book (see Chapter 24) and which cuts across the country, following a somewhat irregular course, from the mouth of the River Exe in the southwest to near the mouth of the River Tees in the northeast. It is roughly the line separating the outcrop of the old Paleozoic rocks on the one hand and the younger Mesozoic and Tertiary rocks on the other. To the north and west of the line lie the remnants of the great mountain chains which were built up by successive earth-building movements of Pre-Cambrian, Siluro-Devonian and


Fig. 15. The Highland and Lowland Zones of Britain

Carbo-Permian times. The mountains are but remnants of their former mighty selves, but they still comprise the major mountain and hill masses of Great Britain. Generally the most ancient masses are those which occur, as in the case of the Highlands of Scotland, farthest to the northwest. Naturally the margins of the ancient rocks are not infrequently covered by strata of later ages.

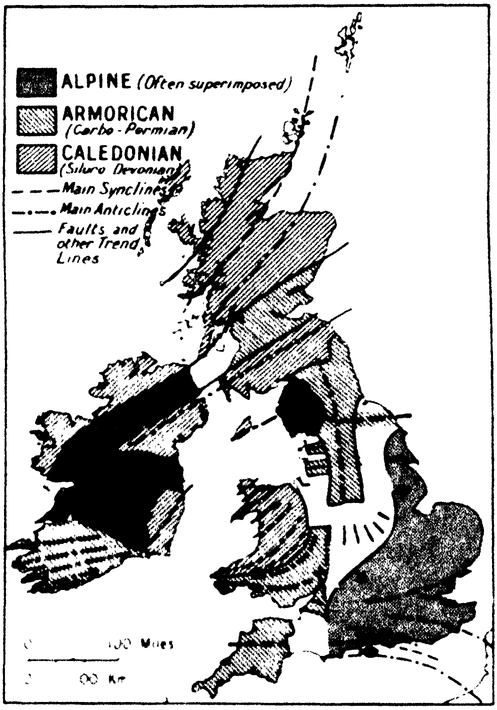



FIG. 16. Morphological map of the British Isles, showing the spheres of influence of the main folding movements

To the south and east of the line one finds first the broad plains or low-lying plateaus, built up mainly of Triassic rocks, which constitute the Midlands of England. Not infrequently small remnants of the ancient mountains stand up as islands in the midst of these plains of younger rocks. Farther southwards and eastwards the Midland plains give place to what may be called, in the broadest possible sense, the scarplands of England. Indeed, it is possible to draw another line across England, again somewhat irregularly, from the Dorset coast to the north Yorkshire coast. To the south and east of this line lie low ridges, separated by shallow valleys, which mark respectively the outcrop of the harder or more resistant and softer or less resistant beds of the geological sequence from the early Jurassic onwards. Like the Triassic rocks of the Midlands, these rocks rest upon an ancient platform which lies buried beneath them at a greater or less depth.

Sometimes, as for example under London, the ancient platform is within 300 metres (1000 feet) of the surface. At other times the Paleozoic platform lies at such a depth that the full thickness of the overlying beds has never been penetrated by the boring tools of the well-engineer. The Jurassic and later rocks have themselves been gently tilted, usually towards the southeast, by the Alpine system of earth movements; but it is only in the extreme south that there are signs of what might be called severe folding.

For the purposes of a preliminary account we may distinguish in Britain the broad physiographic and structural units described in the following pages.

## THE HIGHLAND ZONE

### The Highlands of Scotland

The Highlands of Scotland are built up for the most part of great masses of ancient metamorphic or crystalline rocks—gneiss, schists, slates, and quartzites. Some of the folding doubtless took place in Pre-Cambrian times, and it would seem that some of the great intrusions of granite and of other rocks are of the same date. The great period of earth movements which determined the major structures of the Scottish Highlands was, however, the Caledonian, or Siluro-Devonian. These movements gave rise to great mountain chains with a general trend from southwest to northeast, and this is still the dominant 'grain' of the country. Between the great mountain chains were the deep basins in which the deposits of the Old Red Sandstone were laid down. Much of the Highlands of Scotland has probably remained land from those very remote ages to the present day, and consequently subaerial denudation has gone on almost continuously, culminating with the work of the great ice sheets which covered Scotland during the last glacial epoch. As a result, the Highlands of Scotland of today no longer present the highly accidented scenery of the younger mountain belts of the world, but rather the rounded outlines which betoken the results of aeons of subaerial denudation and the work of ice. On the whole, then, the Highlands form an irregularly surfaced plateau with its greatest elevation along the western margin, sloping on the whole towards the east. The plateau surface has in general an average elevation of between 2000 and 3000 feet (600 and 900 metres); some of the higher points often marking the outcrops of granite, of both Pre-Cambrian and Siluro-Devonian ages. The highest points may reach over 4000 feet (1200 metres), and included amongst them is Ben Nevis, the highest mountain in the British Isles, of 4400 feet (1341 metres). The Scottish Highlands are divided into the Northwest Highlands and the Central Highlands or Grampians by the great cleft of Glen More. The Northwest Highlands are by far the more rugged and the grander, and meet the Atlantic Ocean in the intricate fiorded and island-bounded coast of western Scotland. It seems possible

that the Alpine earth movements, being unable to fold the old stable block, tended to fracture it instead, and the belts of crushed rock which were formed along the fractures have been more easily excavated by rivers and by ice, and by the waves of the ocean, thus giving rise to the fiords with their remarkable rectangular bends.[1] Through some of the major cracks, too, igneous rocks of Tertiary age have welled up and give rise to the marked lava plateaus of Skye and some parts of the western coast of Scotland, comparable in character to those found in Iceland. The Old Red Sandstone, originally deposited in valleys, still tends to occur in valley or lowland

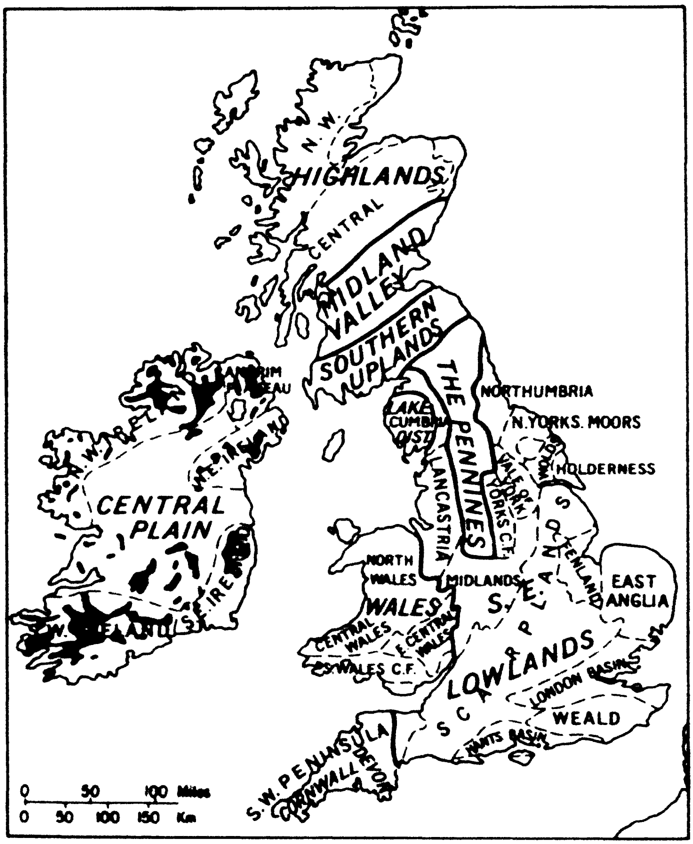



FIG. 17. Physical regions of the British Isles

1. The system of major cracks developed along the western coasts of Scotland may be due to pressure exerted from below by masses of molten rock attempting to find an outlet. Just as when one presses with the point of a stick on a sheet of ice covering a pond, or when a stone is thrown through a window, both concentric and radial cracks would be developed, and it would seem that this explains the varied directions followed by the fiords and valleys of the area. See J. W. Gregory, 'The origin and nature of fiords'; and J. W. Gregory, 'The Scottish lochs and their origin', *Proc. Roy. Phil. Soc. Glasgow*, 45, 1914, 183–96.

situations, but the more resistant rocks of the period may cover considerable stretches, as they do over Caithness.

The ancient rocks of the Highlands on the whole give rise to a poor type of soil, while much of the soil which must previously have been formed has been swept away from most of the higher areas by the ice sheets of the glacial epoch. The tracts occurring on the Old Red Sandstone are, on the whole, more fertile. The same is true of the lower eastern margins of the ancient rocks themselves, as for example in the area known as the Buchan

FIG. 18. The diagram on the left shows cracks which would be developed in a rigid block by pressure from below at a point near the northeast corner. On the right is shown a part of the fiord coast of western Scotland water in black, main valleys dotted

Plateau. Geographically, the eastern margins, whether they are on the ancient rocks or on Old Red Sandstone, are somewhat distinct from the main mass of the Highlands and are frequently considered as a separate region under the title of Northeastern Scotland. It should be noted that the Orkney Islands form a detached portion of this area, whilst the Shetland Islands, farther north, resemble more closely the central part of the Highlands themselves. The southern limit of the Highlands of Scotland is remarkably well defined by the great Highland boundary fault, actually a succession of faults, which runs across the country with a Caledonian trend, from the mouth of the Clyde to the east coast in the neighbourhood of Stonehaven. The faults seem to have been initiated at the same time as the Caledonian earth movements, but intermittent movements along them have undoubtedly occurred from that time until the present.

## The Southern Uplands

The Southern Uplands consist of the denuded remains of a great mountain chain of Siluro-Devonian age, which runs across the south of Scotland

from the southwest to the northeast, that is with a characteristically Caledonian trend. There is, however, a marked difference between the Southern Uplands and the Highlands, in that the rocks of which the Southern Uplands consist are sediments, mainly of Ordovician and Silurian age, very highly folded. In the southwest, particularly in Galloway, there are large

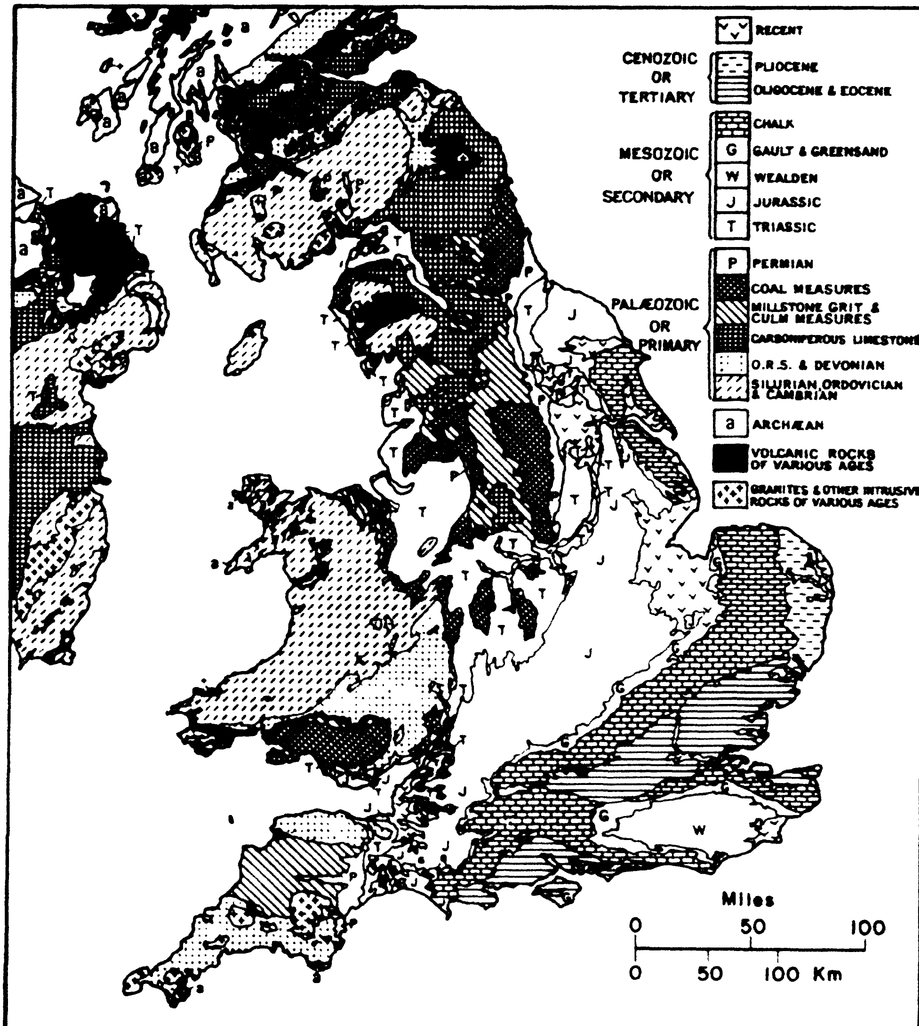



FIG. 19. A simplified geological map of England and Wales

For reference purposes use should be made of the Geological Map of Great Britain on the scale of 1:625,000 (approximately 10 miles to one inch) published in two sheets by the Geological Survey (HMSO).

granitic intrusions, but ancient metamorphic rocks, such as those constituting the greater part of the Highlands, are absent. Consequently all the higher parts of the Southern Uplands are formed of moorland country

with rounded outlines, passing on lower ground in the east, particularly in the Tweed basin, to quiet rolling pastoral, and often well-wooded country. In the southwest, cutting across the main mass of the Southern Uplands, are the well-known dales. These dales are comparatively straight clefts running from north-northwest to south-southeast and afford important routeways. Fringing the Southern Uplands, along the shores of the Irish Sea, are stretches of low ground, occupied by smiling, well-watered pasture. The northern limit of the Southern Uplands is formed by a great zone of faulting, comparable in character to the faultline which bounds the Highlands, though not giving rise to such a marked feature.

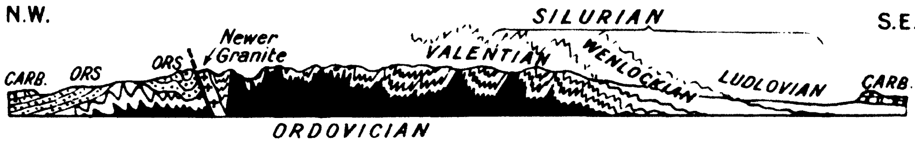



FIG. 20. Section across the Southern Uplands

ORS = Old Red Sandstone; Carb. = Carboniferous

## The Central Lowlands, or Midland Valley, of Scotland

Lying between the Highlands on the north and the Southern Uplands on the south is the great rift valley which forms central Scotland. Initiated by the Caledonian earth movements it was a basin of deposition of the Old

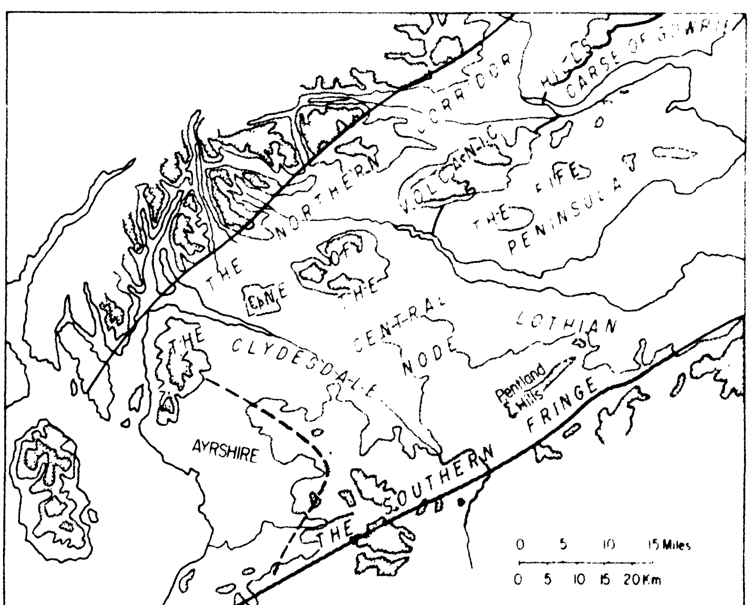



FIG. 21. Subregions of the Midland Valley

Red Sandstone, and was later occupied by a shallow arm of the Carboniferous sea, so shallow that at an early stage it was suitable for the growth of the swamp forests which have left their traces at the present day in seams of coal. At the same period volcanic activity was rife, and as a general result at the present day neither the relief nor the geology of the Midland Valley of Scotland can be described as simple. It is only in the broadest possible sense a valley. It is possible to distinguish a northern fringing corridor or broad valley, then a line of volcanic hills, then the central lowlands wherein lie the great Lanarkshire or Central Coalfield and the Midlothian-Fifeshire Coalfield, then a line of hills along the south and an ill-defined valley separating them in turn from the Southern Uplands. These subdivisions of the valley and their correlation with the geology may be seen in Figs 21 and 22.

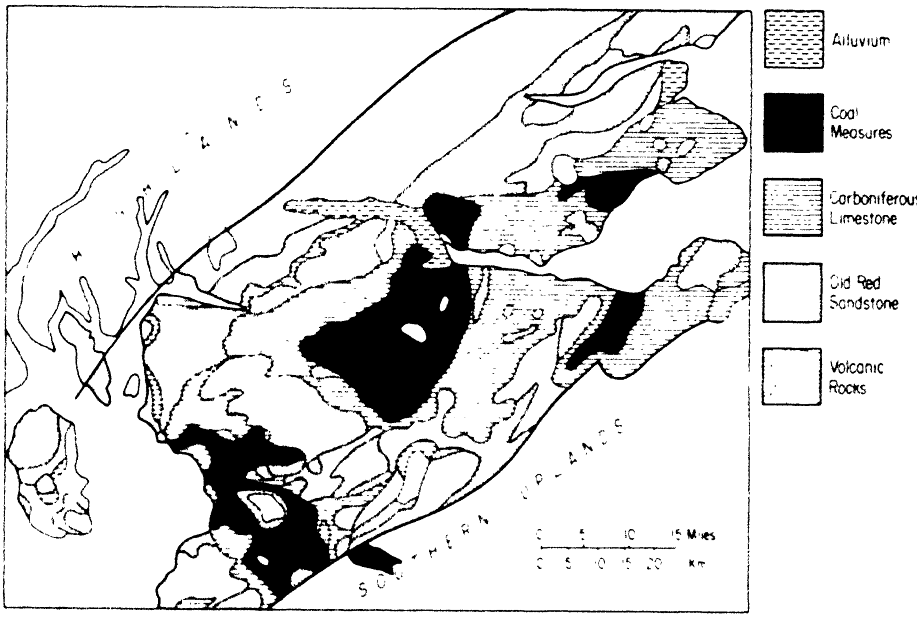



Fig. 22. The geology of the Midland Valley

Note the separation of the Ayrshire and Central coal basins by the Cunningham axis of uplift (NW–SE) and the separation of the Central and Midlothian by the Pentland axis (SW–NE)

## The Lake District or Cumbria

The folding of the mountains which now make up the Lake District probably commenced even as early as Ordovician times, but the main earth movements responsible for the formation of the group were, like those of the Southern Uplands and of the Highlands, the great Caledonian movements. Consequently the geological structures in the main part of the Lake District have a trend from southwest to northeast and there is no doubt that

originally the Isle of Man and the Lake District were joined and formed a single great chain of mountains. But the mountains suffered great denudation, and at a later stage the waters of the Carboniferous sea washed round them and may even have submerged the whole, so that Carboniferous Limestone was deposited on the flanks of the old central core. At a later stage—probably during the Alpine earth movements—a local uplift occurred in the heart of the Lake District. The uplift may have been due to

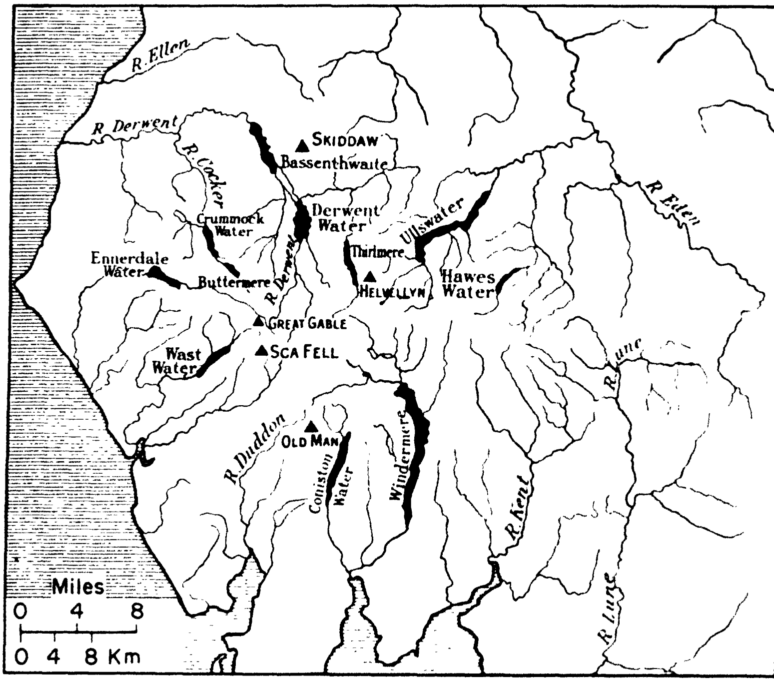



FIG. 23. The radial drainage of the Lake District

a great mass of molten material in the lower layers of the earth's crust attempting, without success, to force its way to the earth's surface. Whatever its cause, the uplift has undoubtedly resulted in the two great characteristic features of the area of the present day. These two features are the occurrence of the main mass of ancient rocks in the heart of the area, surrounded by younger rocks which in general dip away from the centre core. In the second place the uplift seems to have been responsible for the initiation of one of the most remarkable examples of radial drainage which is known. The well-known lakes of the Lake District radiate like the spokes of a wheel from a central hub, and it is because this uplift took place at a comparatively late stage that the forces of denudation are still active. Thus the Lake District has some of the finest rock scenery and, despite their relatively low altitude, rugged mountains in the British Isles. Geographically there is a remarkable contrast between the area of ancient rocks in the

heart of the Lake District and the surrounding ring of younger strata. Only on the southeast do the Shap Fells connect the Lake District proper with the hill masses of the Pennines.

## Wales or the Welsh massif

For the purposes of a general account the whole of the Welsh massif may be considered together. For this purpose the massif may be described as embracing all the hill masses which lie to the west of the English Midlands, excluding only the southern part of the county of Glamorgan, which ought to be considered as part of the English plain or scarplands. The eastern margins of the area so defined can be quite clearly traced from any physical map. In the north the Welsh hills abut quite abruptly on the Cheshire and north Shropshire plain; along the margin lies the North Wales Coalfield. The hills of central and southern Shropshire belong structurally to the Welsh massif, and from central Shropshire southwards to the mouth of the Severn the eastern limit is defined by the line of hills running southwards from the Wrekin in Shropshire to the Abberley Hills and the Malvern Hills. The oldest part of the Welsh massif is in the northwest, where the ancient crystalline rocks of the isle of Anglesey underwent folding in Pre-Cambrian times. The folding was continued during the Caledonian earth movements and post-Carboniferous foldings followed along the same lines, so that one finds narrow bands of Carboniferous Limestone pinched in amongst the ancient rocks. The whole of Anglesey, as the result of later denudation, has been worn down to a low plateau, almost to a sea-level plain, and its complicated geological history is scarcely suggested by the somewhat uninteresting surface features of the island. The mainland of north Wales is still, on the other hand, a land of rugged mountains. On the whole the grain of the country is from southwest to northeast, indicating that the mountains owe their origin in the main to the Caledonian earth movements. The rocks involved in the folding are, for the most part, Cambrian, Ordovician and Silurian, but the mountains owe their rugged character of today to the large masses of contemporaneous lava which were extruded as well as to other igneous masses which were intruded into the rocks before and during the folding. The igneous rocks have proved themselves more resistant to weathering, and most of the higher points, such for example as Snowdon and Cader Idris, mark the outcrop of one or more masses of igneous rock. As one passes from north into central Wales, the igneous masses become less numerous, and this is one reason for the less rugged relief of central Wales. The age of the folding of the rocks, too, becomes successively younger as one goes towards the south. Whilst north and central Wales, which at that time were probably continuous with southeastern Ireland, formed the land mass which we have already called St George's Land in Carboniferous times, South Wales was occupied first by the Carboniferous Limestone sea, then by the fringing swampy lands on which grew the Coal Measure forests.

Coal Measures were laid down over a huge area in south Wales, and at the end of the Carboniferous period were folded by the Carbo-Permian or Armorican earth movements. These earth movements resulted there in folds with an east–west trend, thus causing the great coal basin of the South Wales Coalfield. It would seem that the Armorican earth movements were unable to fold the already highly complicated and hardened masses of north Wales, and that the earth-building waves broke against this resistant mass both along its southern and eastern sides. Thus there are east–west folds in the south, but north–south folds in the east. Some of the latter are remarkably sharp, and one forms that curious line of hills, the Malvern Hills. The Malvern Hills folds are typical of the group with a north–south trend which is sometimes referred to as the Malvernian group. Where the north–south and east–west folds cross, small nodes and basins were formed of which the Forest of Dean coalfield is an excellent example.[1]

It will be seen that a triangular space remains between the east–west Carboniferous folds of south Wales, the north–south Malvernian folds of the eastern margin, and the south–west to north–east Caledonian folds of central Wales. This triangular space is occupied mainly by rocks of Old Red Sandstone age. Where the rocks consist mainly of hard red sandstones and conglomerates, they give rise to high moorland country such as that of the Brecon Beacons, including indeed some of the wildest moorland country in the whole of the British Isles. Where the Old Red Sandstone consists, on the other hand, of comparatively soft red marls lower ground has resulted, in particular the famous fertile lands of central Hereford which is thus a basin lying within the bounds of the Welsh massif. Even here thin irregular limestone bands (cornstones) have resulted in a diversified relief. An attempt has been made in Fig. 25 to divide the Welsh massif into its smaller constituent regions.

## The peninsula of Devon and Cornwall

The southwestern peninsula is the third of the masses of ancient rocks which occur on the western side of England and Wales. It is very different in character from the Lake District massif, and also from the Welsh massif. The folding of the rocks is very complicated and took place, for the most part, during the Carbo-Permian or Armorican earth movements, and the strike of the folds is east to west. During the folding there was an intrusion of large granite masses. Thus from early Permian times onwards, as already pointed out, there must have been great east and west mountain chains separated by deep rock-girt basins in which the Permian and Triassic rocks were laid down. But through the long ages since, denudation has been active, and the ancient mountain chains have been worn down until now there are certainly no rugged mountains in Devon or Cornwall. Instead

1. Still better shown in the complicated Bristol district, and the Mendips.

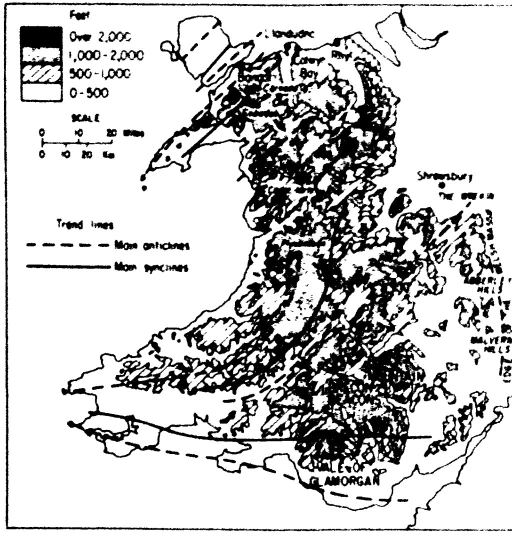



FIG. 24. Physical map of Wales showing trendlines

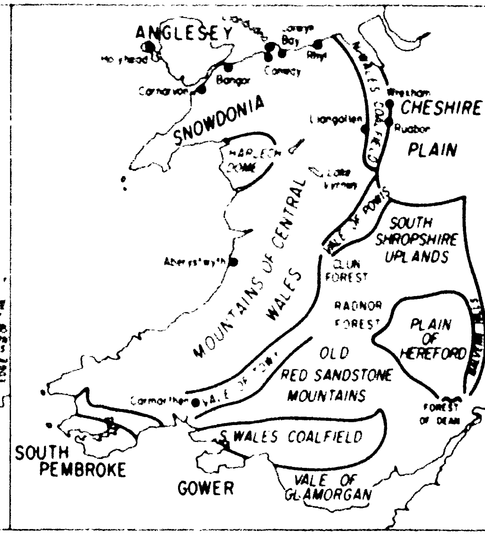



FIG. 25. Wales, showing a division into physiographic regions

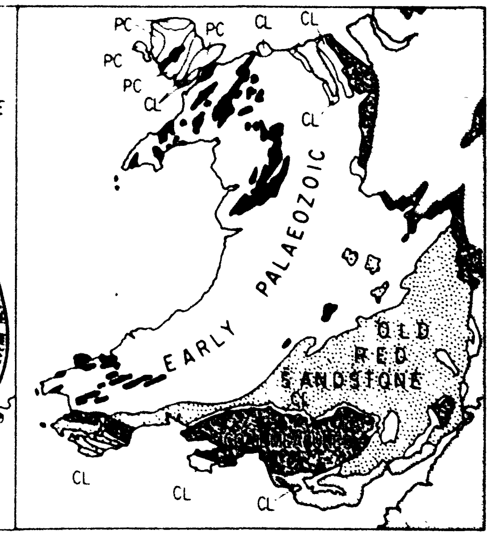



FIG. 26. Geological map of Wales

Black = igneous rocks; PC = Pre-Cambrian; CL = Carboniferous Limestone

there is an elevated plateau rising to its greatest heights either where the old rocks are very hard or tough, as in Exmoor, or where the granite masses have offered a greater resistance to denudation than the surrounding sediments, as they have in Dartmoor and Bodmin Moor and other areas. The

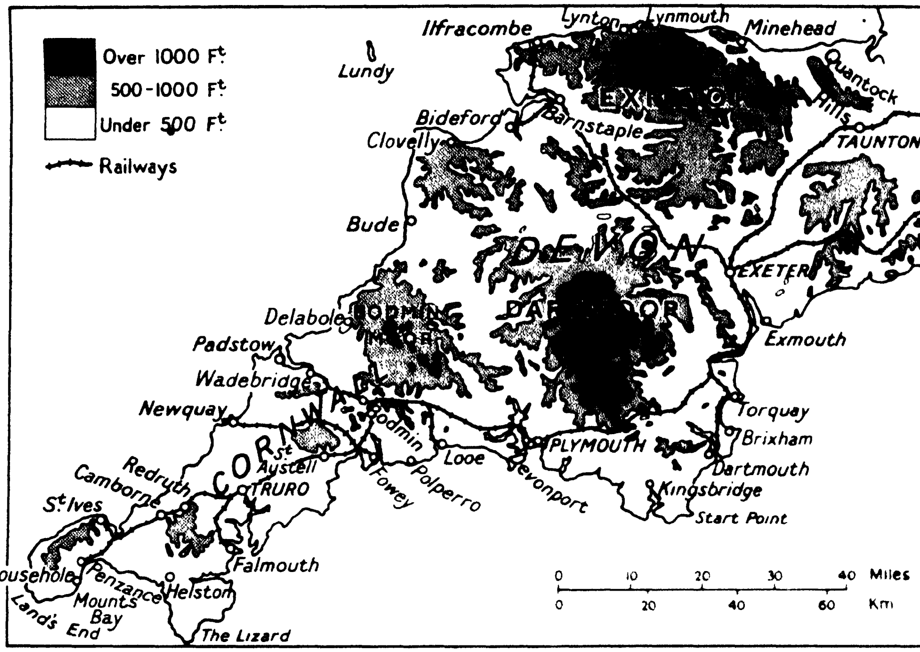



FIG. 27. Physical and general map of the southwestern peninsula

southwestern peninsula also seems to have undergone, at least since mid-Tertiary times, a general though intermittent uplift, so that at the present day we may best describe the area as a succession of plateaus or platforms generally believed to be of marine origin --plateaus which meet the present ocean in the long succession of rugged cliffs, so characteristic of the coasts of Devon and Cornwall. It should be mentioned that a part of western Somerset (the Quantocks) is also included within this region. The higher levels are occupied by moorlands, but much of the remainder is cultivated, since the Devonian and Carboniferous rocks break down into a moderately rich soil. The comparatively mild climate, especially of the more sheltered valleys, is responsible for the special vegetation and utilisation features of these valleys both in Devon and Cornwall.

## The Pennines

The Pennines, or the 'Backbone' of England, are sometimes wrongly referred to as a chain of mountains. This term is entirely incorrect, and it is not wise to apply even the term 'range' to them. It is much more suitable

that they should be referred to as the Pennine Upland. It is probable that Coal Measures were deposited, as we have already seen, right across the north of England, and that the Pennine Uplift dates from post-Carboniferous times, that is from the the Carbo-Permian earth movements. The

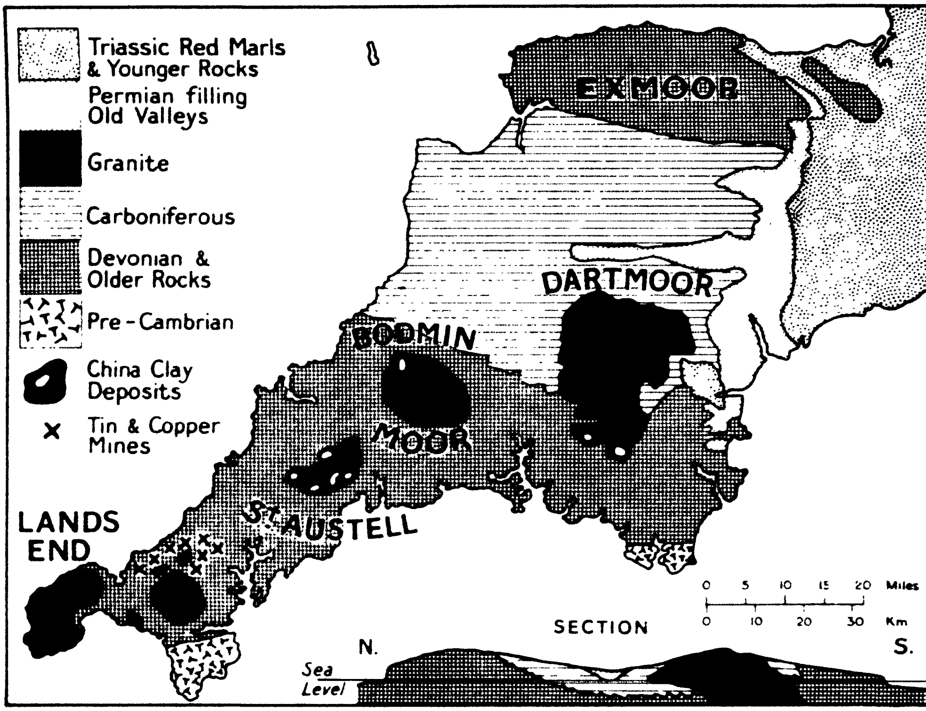



Fig. 28. Geological sketch map of the southwestern peninsula

A comparison with Fig 27 will suggest the correlation between the granite masses and higher areas of the plateau surface with Exmoor as an exception. The section is from Exmoor through the Dartmoor granite.

Pennines are often represented in diagrammatic sections as if they were a simple anticline. Broadly speaking, however, the fold, if such it may be called, is defined by a series of great faults on the west, and consequently the highest portion of the Pennines is usually the western margin overlooking the lowlands to the other side of the boundary faults. The Carboniferous Limestone and Millstone Grit rocks which make up the bulk of the moor-covered Pennine Uplands are themselves but slightly folded, often almost horizontal, but towards the east they take on a general dip towards the North Sea, so that on the eastern side the Pennines fade gradually into the lower ground bordering the North Sea itself. Important transverse valleys divide the Pennines into four blocks; these are shown on Fig.29 in relationship with the main outcrops of Carboniferous Limestone and Millstone Grit. In the north the Cheviot Hills, largely built up of volcanic material, form a connecting link between the Pennines and the Southern Uplands of Scotland.

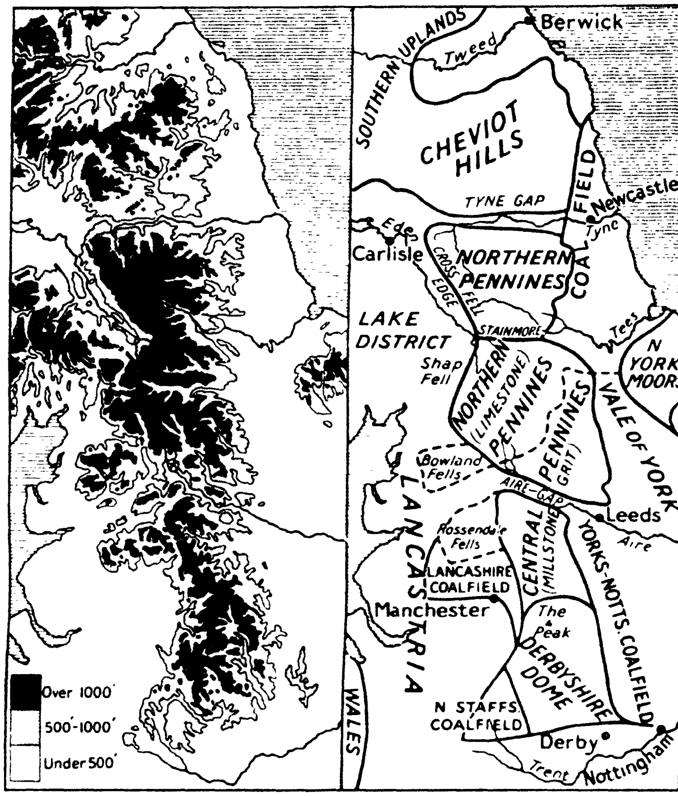



FIG. 29. The Pennines

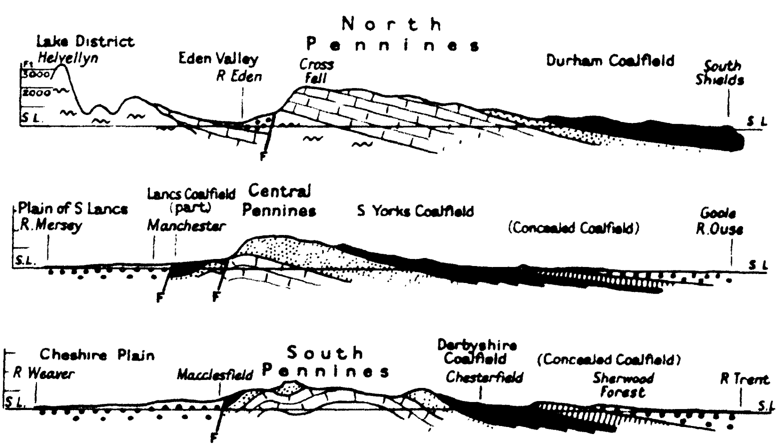



FIG. 30. Sections across the Pennines

The geological formations shown are: Lower Paleozoic Slates (wavy lines), Carboniferous Limestone (brickwork), Millstone Grit (dots), Coal Measures (black), Magnesian Limestone (vertical lines), Trias (circles). Note the asymmetrical character of the uplift and the variation in structure from north to south.

THE LOWLAND ZONE

The remainder of England is occupied for the most part by lowlands, and is built up mainly of rocks younger than those which form the Highland Zone. For purposes of description, the following broad regions may be distinguished.

## The Triassic plain of the Midlands

The Midlands of England, in a somewhat restricted sense, consist for the most part of lowland, and occupy a V-shaped area. The southern end of the Pennines fits into the centre of the V, the left arm of which joins the lowlands of Cheshire and Lancashire, through the Midland Gap, while the right arm joins the lowlands of the Vale of York by way of the broad lower Trent Valley. Geographically the Midlands so defined may be regarded as bounded on the southeast by the first of the scarps which make up the scarplands of southeastern England. On the west the Midlands

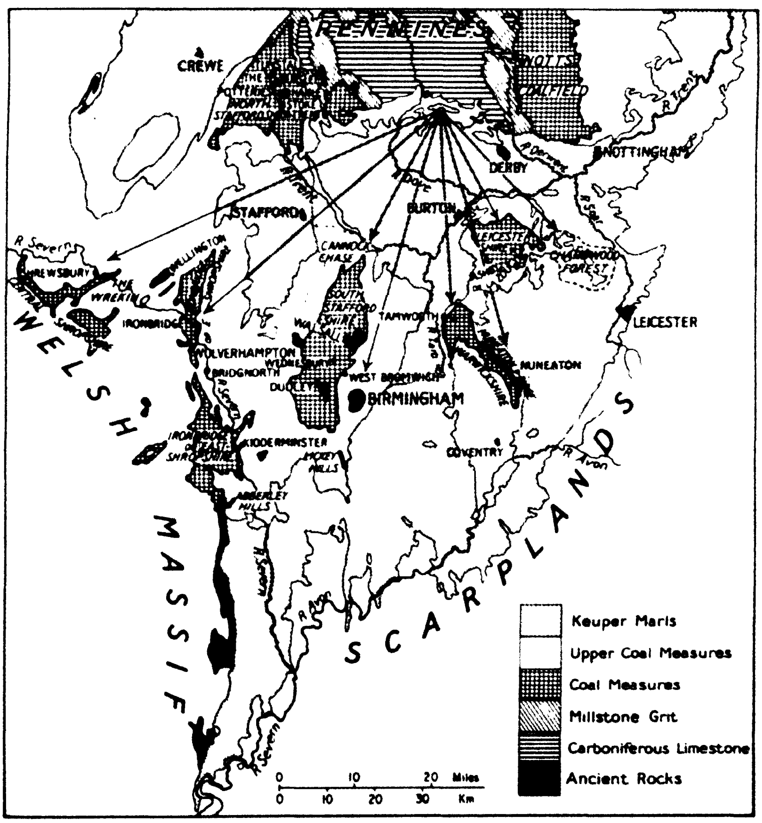



FIG. 31. The ancient islands of the Midlands

stretch as far as the edge of the Welsh massif, which has already been described. The point of the V stretches to the Severn estuary and extends through the interesting, if complex, Bristol–Mendip region into the Plain of Somerset. The most important of the geological formations in the Midlands is the Upper Trias or Keuper Marls with the fine-grained Keuper Sandstones, which weather to a rich red soil excellent for cattle pastures and

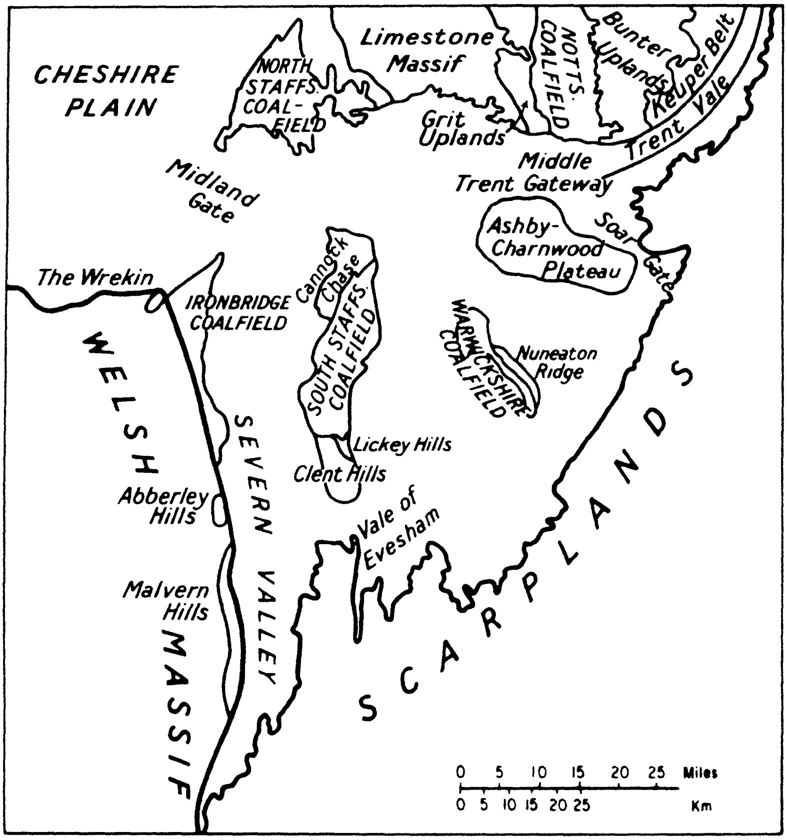



FIG. 32. Sketch map showing physiographic subdivisions of the Midlands. The northeastern part is after Professor H. H. Swinnerton

for cultivation. The Triassic Marls are very similar to the Old Red Marls of Herefordshire. Both give rise to lowlands. The Lower Trias or Bunter is a formation of sandstones and pebble beds which results in rather higher and less fertile country, such as the Cannock Chase plateau. The whole of the Trias, as already explained in Chapter 2, was originally laid down in a shallow inland basin under almost desert conditions (compare the Great Salt Lake of Utah at the present day), and the Triassic deposits are found wrapping round masses of older rock which formed islands in the old lake basin. The 'islands' include the small coalfields of the Midlands, and since

they give rise to industrial areas in the midst of country otherwise agricultural they should be considered separately, together with the 'islands' of still older rocks.

*The 'islands' of old rocks in the Midlands.* These islands of old rock are best considered in relation to the southern end of the Pennines. Taking a point at the southern end of the central limestone core of the Pennines, just west of Derby, it is possible to draw radiating lines each passing through one of the old islands. This has been done in Fig. 31.

*Charnwood Forest* lies to the southeast of the southern Pennines. It consists of very ancient (Pre-Cambrian) rocks, though all but the highest hills of the ancient island have been covered with Triassic deposits. But the geology makes Charnwood Forest quite different from the surrounding country. There are pretty wooded hills and winding leafy lanes, and the whole area is one of the playgrounds of the Midlands. Some of the old rocks are quarried for road metal, which is used all over southern England.

*The Leicestershire coalfield* lies next to Charnwood Forest on the west. It is one of the few coalfields of England which has not given rise to an extensive industrial area. The coalfield and Charnwood Forest form an upland area which has been called (as on Fig. 32) the Ashby-Charnwood Plateau.

*The Nuneaton Ridge*, a narrow ridge of ancient rock including the Cambrian Hartshill Quartzite, lies almost due south of Derby.

*The Warwickshire coalfield*, sometimes called the Nuneaton Coalfield, lies to the west of the Nuneaton Ridge, just as the Leicestershire field lies to the west of Charnwood Forest.

*The Lickey Hills.* Slightly west of south from the centre of the Pennines a line passing through Birmingham reaches a very small island of ancient rocks comparable with the Nuneaton Ridge—these are the Lickey Hills.

*South Staffordshire coalfield.* This large and important coalfield lies immediately to the northwest. The northern part is a broad plateau, continued northwards by Bunter Sandstones and known as 'Cannock Chase.' Associated with the southern part of this coalfield is the famous 'Black Country.' A hard breccia at the top of the Coal Measure sequence gives rise to the ridge of the Clent Hills.

*The Ironbridge and Forest of Wyre coalfield* (East Shropshire Coalfield) is a long, narrow coalfield stretching southwards from Wellington and lying along the edge of the Welsh massif. It is cut through by the gorge of the Severn.

*The Wrekin*, a hill of ancient rocks near Wellington, has already been mentioned as part of the outer rampart of the Welsh massif. It is part of the area of old rocks which occupies central Shropshire.

Having now dealt with the islands of old rocks which give rise to most of the industrial areas of the Midlands, it remains to note a few points about the surrounding regions of Triassic rocks.

The Bunter Sandstones and Keuper Sandstones, as already noted, coincide with low uplands, the Keuper Marls with low ground, gently undulat-

ing but otherwise rather featureless. It must be remembered that over very many areas the underlying solid rocks are masked by the glacial drifts.

To the southeast the Keuper Marls are succeeded by the Rhaetic and Liassic rocks. Unless the Rhaetic or lower Lias contains hard or resistant beds sufficiently important to give rise to a scarp there is little to mark the junction. Thus the Vale of Evesham is partly on Keuper, partly on Lias; so also is the Vale of Berkeley.

## The plain of Lancastria

The plain of Lancastria forms a continuation of the Midland Plain through the Midland Gap or Midland Gate. It occupies the northern half of Shropshire, nearly the whole of Cheshire and that part of Lancashire which lies between the Pennines and the Irish Sea. There are two broad tongues of moorland, called respectively Bowland 'Forest' and Rossendale 'Forest', which extend westwards from the Pennines into Lancashire and which coincide with outcrops of Carboniferous Rocks (Millstone Grit and Lower Coal Measures). Again, where Bunter or Keuper sandstones outcrop there may be low hills, as in Delamere Forest. Elsewhere, the Lancashire Cheshire plain is an undulating lowland underlain by Keuper Marl; the actual character of the surface, however, depends largely on the thickness and type of the mantle of glacial deposits. Physically the plain of Lancastria lies between the Welsh massif and the Pennines: on the west the undulating country of the North Wales Coalfield forms a transition belt; in the east the coal measure country of the North Staffordshire Coalfield forms another transitional belt.

## The northeastern lowlands

These lie in Nottinghamshire, Yorkshire, Durham and Northumberland. On the eastern side of the Pennines, and thus corresponding to the Plain of Lancastria on the west, is a broad belt, mainly of lowland. The Carboniferous Limestone and Millstone Grit formations which make up the bulk of the Pennines dip eastwards, and are succeeded in turn by the Lower Coal Measures, the Middle and Upper Coal Measures, the Magnesian Limestone and higher Permian beds, the Bunter Sandstone and the Keuper Marls. In general terms each succeeding formation gives rise to its own characteristic type of country. Thus there is a succession of physiographic zones roughly parallel to the Pennines. The Lower Coal Measures give rise to rather barren land with patches of moorland separated from one another by river valleys. The more fertile country of the Middle and Upper Coal Measures has a gentler relief, but resistant beds may form westward facing scarps (see Fig. 188). Tongues of lowland extend into the heart of the Pennines along the famous 'Yorkshire Dales'--particularly those formed, from north to south, by the Swale, Ure, Nidd, Wharfe, Aire,

Calder and Don. The Magnesian Limestone usually forms a distinct westward facing scarp, often with attractive cliff scenery, especially at those places where the scarp is cut through by rivers. The Bunter Sandstone, as in the Midlands, coincides with sandy, rather elevated tracts, infertile and hence often well wooded as in the Sherwood Forest. Occasionally marked bluffs are found, such as that on which Nottingham Castle is situated. The final belt is that of the Keuper Marls and is the lowland belt which stretches from the mouth of the Tees to the Trent Vale of Nottinghamshire, but the Keuper Marls are masked by superficial deposits over large areas, particularly over that huge tract known as the Vale of York, and the interesting area of the Isle of Axholme.

## The Bristol-Mendip region

To the southwest the Midland Plain narrows and passes first into the Vale of Gloucester and then into the Vale of Berkeley between the Forest of Dean or the Severn on the west, and the fine scarp of the Cotswolds on the east. But farther southwards, in what may be called the Bristol–Mendip Region, the plain disappears. Its place is taken by country of varied relief

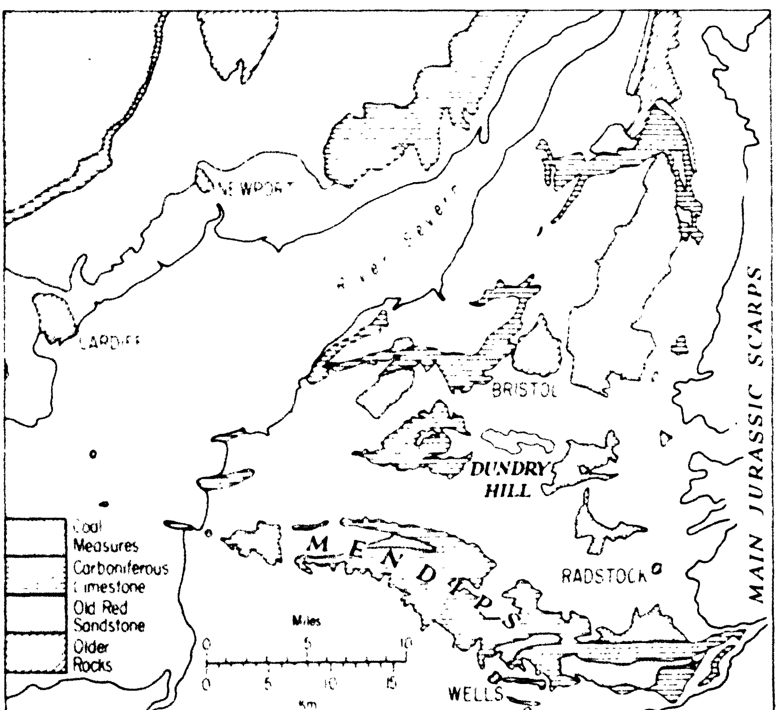



FIG. 33. The Bristol-Mendip region, showing the islands of old rocks. The unstippled land areas are Triassic and lower Jurassic rocks and recent deposits

lying between the Severn and the westernmost of the Jurassic scarps. This region repeats, on a smaller scale, the features of parts of the Midlands. It really consists of 'islands' of old rocks wrapped round by the softer Triassic and Liassic deposits. But there are several points of difference: the islands are relatively larger and more numerous, the amount of low ground correspondingly small. The islands, too, are of rocks of varied age; there are the large Carboniferous Limestone masses of the Mendip Hills, and the important coal basins, as well as quite tiny patches of Silurian, Old Red Sandstone and Carboniferous Limestone. The 'islands' are remnants of Armorican folds, and it is in this region that the north–south Malvernian folds cross the more normal east–west folds. Thus some of the old blocks are elongated in a north–south direction, such as the Tortworth Ridge north of Bristol and the Carboniferous Limestone edges of the Kingswood coal basin. In the Mendip Hills a succession of east–west folds *en echelon* has resulted in a broad upland trending from westnorthwest to eastsoutheast.

## The plain of Somerset

In some ways this plain resembles that of the Midlands from which it is separated by the Bristol–Mendip region. The Vale of Taunton Deane is thus a Keuper Marl lowland, but the great feature of Somerset is the very extensive plain, almost at sea-level and liable to extensive floods, which lies between the Quantock Hills and the Mendip Hills, and which is interrupted only by the narrow Liassic ridge of the Polden Hills.

## The Jurassic scarplands

The Jurassic rocks of Britain crop out over a belt of varying width extending from the Dorset coast to the north Yorkshire coast. Over large areas the beds dip to the southeast or east, and so give rise to a succession of hills or ridges where the harder or more resistant beds crop out, and valleys or negative relief where the softer or more easily eroded rocks occur. The hills usually have a steep scarp slope on the one side, generally to the northwest, and a long gentle dip slope on the other. While the general arrangement is that suggested in Fig. 34, it is a mistake to imagine a continuous Jurassic limestone scarp running right across the country. The hill belts and scarps are not formed by a single rock formation, but by different rock groups in different areas. The scarps swing about in different directions, die away, and start again. In some parts of the Midlands, the dip slope of the resistant beds is so slight that the structure of the country becomes that of a dissected plateau. Thus the Jurassic scarps are not nearly as constant as that of the Chalk.

In the first place the Jurassic rocks were laid down in shallow water, and consist of a varied series of clays, fine and coarse sands, sandstones and limestones. Some of the latter are oolitic, but the importance of the oolitic

limestones has been overemphasised as a result of their economic value as building stones or for lime. The variability of the Jurassic succession was enhanced by the presence within the sea of three axes of uplift which, by separating the sea into four different basins, allowed a different succession of clays, sands and limestones to accumulate in each basin. Along the axes, which lay respectively east–west across south Yorkshire, northwest to southeast across Oxfordshire and westnorthwest to eastsoutheast along the line of the Mendip Hills in Somerset, the whole Jurassic sequence is naturally thin.

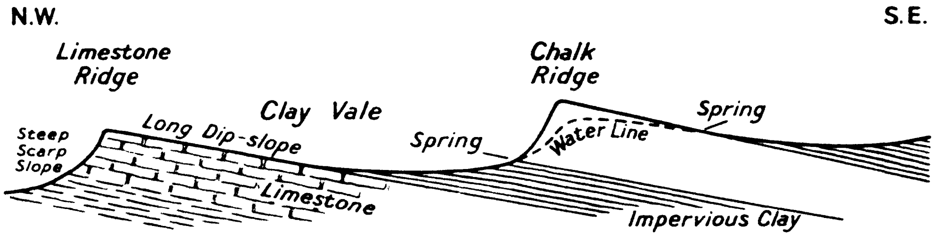



Fig. 34. Diagrammatic section illustrating the succession of clay vales and limestone or sandstone ridges found in the southeast of England

An attempt has been made in Fig. 35 to show the actual position of the true scarps.[1] Those shown have a minimum slope of 1 in 10. The scarplands may be divided as follows:

1. *The northern basin of deposition.* The Cleveland and Hambleton Hills of North Yorkshire. Here the wavy dissected scarp, 200 metres (600 ft) high, with its deep valleys and its plateau-like surface, is formed by thick sandstones of Inferior and Great Oolite age, accentuated by the resistant nature of the underlying Upper and Middle Lias beds which form the lower portion of the cliff. There are also tabular hills of Corallian rocks.
2. *The Market Weighton uplift* of South Yorkshire. The thin Jurassic rocks are overlapped by the Chalk and there is no Jurassic scarp.
3. *The central basin of deposition*—in Lincolnshire and Northamptonshire.
   (*a*) In Lincolnshire the remarkable Lincoln Cliff, from 30 to 60 metres (100 to 200 ft) high, runs north and south in an almost straight line, broken only by the Witham Gap on which Lincoln is situated. It is formed by the Lincolnshire Limestone (Inferior Oolite); to the west is the low ground on soft Liassic Clays; to the east low ground again.
   (*b*) In south Lincolnshire and Leicestershire there are three distinct scarps. The Rhaetic and Lower Lias limestones form a small ridge, of no great extent, some 16 kilometres west of Grantham. Eastwards are wide lowlands on Lower Lias Clays; then, beginning near Caythorpe, and increasing in height as it swings south-westwards to form the Melton

1. For full details see S. H. Beaver, 'The Jurassic scarplands', *Geography*, **16**, 1931, 298–307.

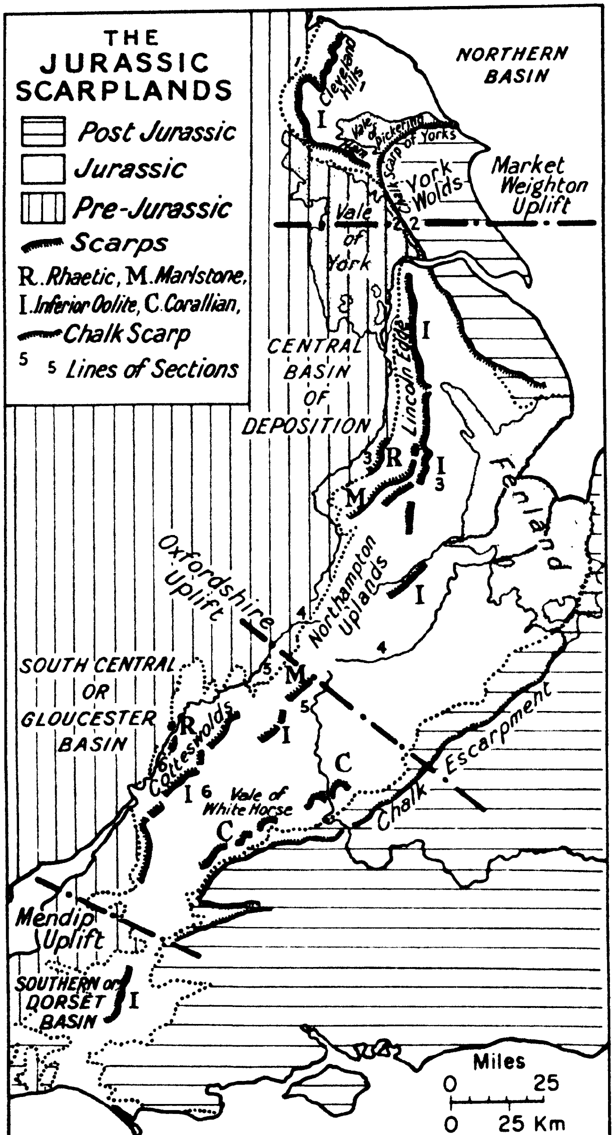



FIG. 35. The Scarplands of England

Mowbray ironstone ridge, is the scarp, about 45 metres (150 ft) high, formed by the Middle Lias marlstone. Farther east is the Upper Lias clay vale, then a scarp 60 metres (200 ft) high which marks the edge of a Lincolnshire limestone plateau. The last scarp continues, rather more broken, south of Grantham and overlooks the Vale of Catmoss in Rutland and the Welland Valley in Northamptonshire.

(*c*) In eastern Warwickshire and Northamptonshire there are really no scarps (partly owing to Boulder Clay cover), but instead an undulating area and a watershed where a number of important streams rise. Many of the rocks present are resistant, so the area is in the main an upland.

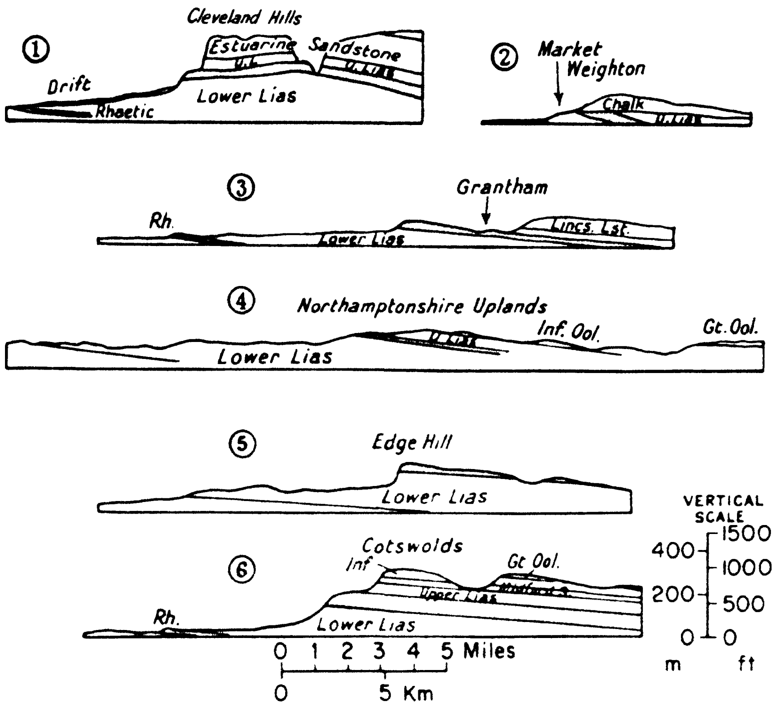



FIG. 36. Some typical sections across the scarplands

The numbers refer to the lines of section shown on Fig 35. Stippled band = Middle Lias mainly sandstone and marlstone

4. *The Oxfordshire Uplift* in southeastern Warwickshire and north Oxfordshire. Here the Lower Lias limestones continue to form an upland and the Marlstone makes the marked feature of Edge Hill, but the Inferior and Great Oolites are poorly developed and give rise to undulating ground.
5. *The South-Central or Gloucestershire Basin of Deposition.* Here the great scarp of the Cotswolds, 200 metres (600 ft) high, dominates the whole country. The scarp is formed in the main by the Midford Sands and the limestones and grits of the Inferior Oolite, but the extensive dip slope is usually capped by the Great Oolite limestone and Forest Marble. Frequently the main scarp is 'stepped', a lower step or shelf being formed by the Middle Lias Marlstone. To the west there is locally a small Rhaetic scarp; to the east the Cotswolds slope gradually towards the great Clay Vale (including the Vale of the White Horse) and only in some places is the eastern side of the Vale interrupted by a small scarp formed by the Corallian.

6. *The Mendip uplift.* The Oolitic escarpment ceases to be clearly recognisable south of Bath. All the Jurassic divisions tend to become thin and to lose their normal lithological character towards the Mendips where there was an axis of uplift during the time of their deposition.
7. *The southern or Dorset basin of deposition.* Southwards from the Mendips the Jurassic succession resumes again its normal features (in the Dorset basin of deposition), and the Oolites, together with the Upper Lias, form a prominent escarpment of Cotswold type separating the Vale of Blackmore on the south from the Somerset lowlands on the north. In detail, the area is very complex as there are no less than eleven different resistant beds which in places form scarps. Farther south the area is dominated by the Upper Greensand scarp of the Blackdown Hills.

It will be clear that the great Clay Vale is formed in the main by the clays of the Upper Jurassic. In Yorkshire it is represented by the old glacial lake basin of the Vale of Pickering (on Kimmeridge Clay). The Lincoln Vale is on the Oxford and Kimmeridge clays, and broadens out southwards to the great flat of the Fens where the solid geology is completely masked. Beyond this is the clay vale drained by the middle portion of the Ouse, on which stands Bedford. A low divide separates this area from the wide clay Vale of Aylesbury in the drainage basin of the Upper Thames. This Vale owes its existence to the thick and almost continuous succession of Upper Jurassic and Lower Cretaceous Clays. It is continued westwards in the Vale of Oxford, and the Vale of White Horse, but here the clay vale becomes interrupted by the Corallian scarp, and there are local features, such as Shotover Hill, formed by Portlandian rocks.

The accompanying sections illustrate not only the scarp-forming formations, but also the general Jurassic sequence.

## The chalklands

The fine white limestone known as chalk, although soft, is more resistant to weathering than the clays or sands which underlie it and the more recent sediments by which it is sometimes succeeded. As a formation it is thick—about 200 to 300 metres (600 to 1000 ft) generally—and varies but little from Yorkshire to the Isle of Wight. Consequently it gives rise to a scarp, in general westward facing, which is both more conspicuous and more continuous than the scarps formed by the Jurassic rocks. Only rarely—as in the East Anglian Heights—is this feature inconspicuous, even more rarely almost absent. The dip slope of the chalk is characteristically 'rolling' country and innumerable dry valleys are a constant feature. Where the chalk is almost horizontal large stretches of rolling downland (typified by Salisbury Plain) result; where the dip of the beds is steep there is little difference between the dip slope and the scarp slope and 'hog's back' lines of hills result, like the Hog's Back between Guildford and Farnham. The

belt of chalklands commences in the north in Yorkshire (where it forms the Yorkshire Wolds). It is interrupted by the Humber and forms the ridge through which that river passes just before reaching Hull. Southwards are the Lincolnshire Wolds, as far as the second interruption caused by the Wash. In both the Yorkshire and the Lincolnshire Wolds the character of the chalklands is modified by a thick mantle of glacial deposits. From the chalk cliffs of Hunstanton in Norfolk the scarp is represented merely by low hills overlooking the Fens. In the neighbourhood of Newmarket, the chalk hills become more distinct (East Anglian Heights) and gradually the great


FIG. 37 The Chalklands of England

stepped scarp of the Chiltern Hills becomes increasingly marked. The River Thames cuts through the chalk ridge by the Goring Gap. In Berkshire and northern Wiltshire the chalk outcrop broadens to form the Lambourn and Marlborough Downs. In this part of England certain beds below the chalk, especially the Upper Greensand (here a close-grained loamy clay), assume a special significance. The important Vale of Pewsey is floored by the Upper Greensand and the morphological features of this Vale are particularly interesting. To the south is the great stretch of Salisbury Plain. The chalk downs extend into Dorset. From there westwards an important feature is formed by the Greensand deposits—here with more resistant beds—which give rise to the Blackdown Hills.

Along the south coast tracts, Britain was considerably affected by the Alpine earth movements, and the highly folded chalk—almost vertical in places—gives rise to a ridge through the Isle of Purbeck and then the Isle of Wight.

To the north and south of the Weald are the North Downs and South Downs respectively (see Fig. 38).

## The Weald

Originally the whole of southeastern England was covered with a thick mantle of chalk, and the uplift of the Wealden dome took place during the Alpine earth movements. The crest of the dome, which is elongated from east to west, trends on the whole in that same direction, but the axis curves towards the southeast when followed over the Strait of Dover into the northern part of France. The Weald of Kent, Surrey and Sussex forms classic ground in many respects, for it was here that W. M. Davis[1] studied the evolution of the river system and applied the following terms which are


FIG. 38. Diagrammatic section across the Weald from north to south

now commonly used. From the central ridge of the upfold, the rivers drain off to north and to south. Their direction was a consequence of the structure of the ground, and hence such streams are called 'consequent'. As the rivers and other agents of denudation continued their work so the chalk was entirely removed over the central area and the underlying rocks were exposed. The softer beds, such as the clays, were worn away by streams running into the consequent rivers at right angles. These streams developed subsequently to the earlier ones and so are called 'subsequent'. Still smaller streams, which joined these at right angles in such a way that their direction of flow was often opposite to that of the consequent streams, are known as 'obsequent'. The rocks underlying the chalk in the Weald belong to the Lower Cretaceous Series, and there are alternating soft, or easily eroded, beds, mainly clays, and harder, or more resistant beds, mainly sands and sandstones. One thus has a repetition in miniature in the Weald of the features of the scarplands of England, with each successive ridge showing a scarp facing towards the centre, as suggested in Fig. 38. At a late stage in the history of the area, the Strait of Dover was cut and occupied by the sea across the eastern end, so that the extreme east of the Weald is actually in

1. 'The development of certain English rivers', *Geogrl J.*, 5, 1895, 127.

France. In the heart of the Weald as it is today is a group of sandy beds forming hills once covered with thick forest, and so often known as the Forest Ridges. Surrounding these hilly central tracts is a belt of lowland where the Weald Clay and certain other clayey beds are found, then a belt of hills formed by the harder beds of the Lower Greensand, then again a valley, called Holmesdale in Surrey and Kent, which marks in the main the position of the soft Gault clay. Then comes the main ridge of all, formed by the chalk, well known as the North Downs in the north and the South Downs in the south. The Downs present a steep scarp slope inwards towards the heart of the Weald, and then a long gentle dip slope in the reverse direction. Sometimes the dip of the chalk is steep, as in the famous Hog's Back west of Guildford, and the apparently simple structure shown in the diagram may be complicated locally, especially where the escarpments are 'stepped' and certain horizons, e.g. the Lower Chalk, give rise to platforms. Although the Weald is thus a well-marked region, it will be seen that it comprises a number of different parts, which may now be separately considered.

*The Forest Ridges or the High Weald*, usually built up of various groups of sand, particularly the Ashdown Sands, the Tunbridge Wells Sands, and the Hastings Sands, once densely forested and important for the supply of timber for charcoal for the now defunct iron industry.

*The Weald Clay Vale*, a region of negative relief, still very wet, mainly occupied by pasture lands with scattered remnants of the once continuous cover of damp oak woodland. It is a tract in which older settlements and villages are relatively few.

*The Greensand Ridge* or the tract of well drained land with numerous springs on the flanks. Sometimes the land is highly cultivated, but where the sand is coarse the soil may be poor and there are wide stretches of heathland. The Greensand Ridge passes towards the western edge of the Weald into a broad tract of undulating, dry, heathy country which has been called the Western Heights. It should be noted that the Lower Greensand does not give rise to a distinctive region on the southern side of the Weald.

*Holmesdale* is another tract of damp clay lands, but at the foot of the downs there is usually a strip where the Upper Greensand and Lower Chalk outcrop and where there are good, rich mixed soils, largely cultivated.

*Romney Marsh* is a separate area within the Weald, now drained and occupied by pastures, whilst *Pevensey Marsh* is a similar area though its utilisation is different (see p. 253).

Strictly speaking the Weald may be regarded as limited by the main crest of the chalk scarp, but it is often convenient to consider as belonging to it the chalk downs as well. When one remembers that the chalk ridge maintains an average elevation of about 150 to 220 metres (500 to 700 ft), and that there is a drop of 120 metres (400 ft) or more to the Gault Clay Vale, the importance of the gaps through the ridge is at once apparent. Along the

North Downs the chief gaps and gap towns from west to east are (the letters refer to Fig. 39):

(*a*) The Wey Gap—Guildford.
(*b*) The Mole Gap—Leatherhead and Dorking.
(*c*) The Merstham Dry Gap—Redhill and Reigate.
(*d*) The Darent Gap—Otford and Farningham.
(*e*) The Medway Gap—Rochester.
(*f*) The Stour Gap—Canterbury.

Along the South Downs are:

(*a*) The Arun Gap—Arundel.
(*b*) The Adur Gap—Steyning.
(*c*) The Ouse Gap—Lewes.
(*d*) The Cuckmere Gap.

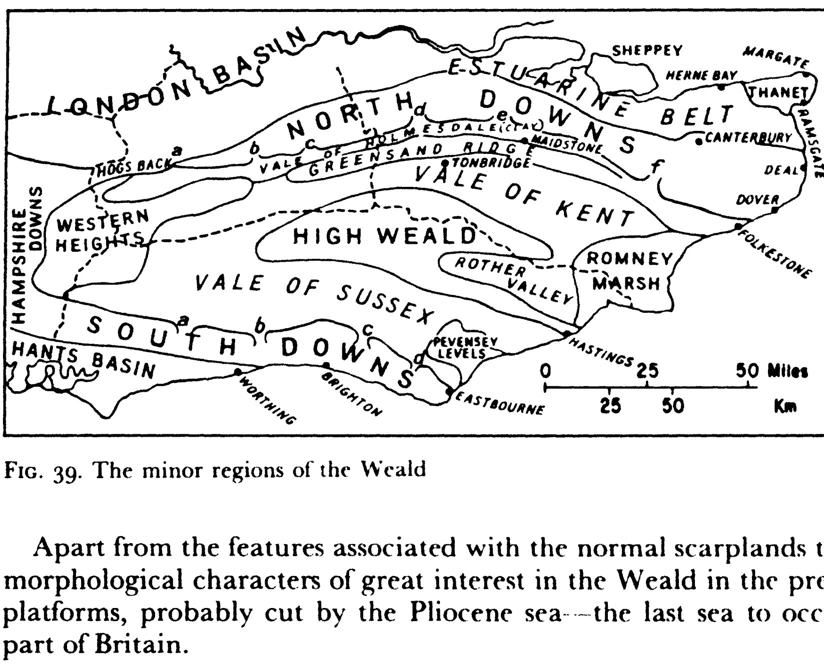



FIG. 39. The minor regions of the Weald

Apart from the features associated with the normal scarplands there are morphological characters of great interest in the Weald in the presence of platforms, probably cut by the Pliocene sea—the last sea to occupy this part of Britain.

## The London Basin

The London Basin is both a geographical and a geological unit. Geologically, it is a broad synclinal basin with a clearly defined chalk rim and a central portion occupied by sands and clays of the Tertiary sequence, by gravels of varied origin, and by alluvium. The chalk which underlies the London Basin in turn rests directly, or with but a small intervening thickness of older deposits, on the ancient Paleozoic platform which, like its

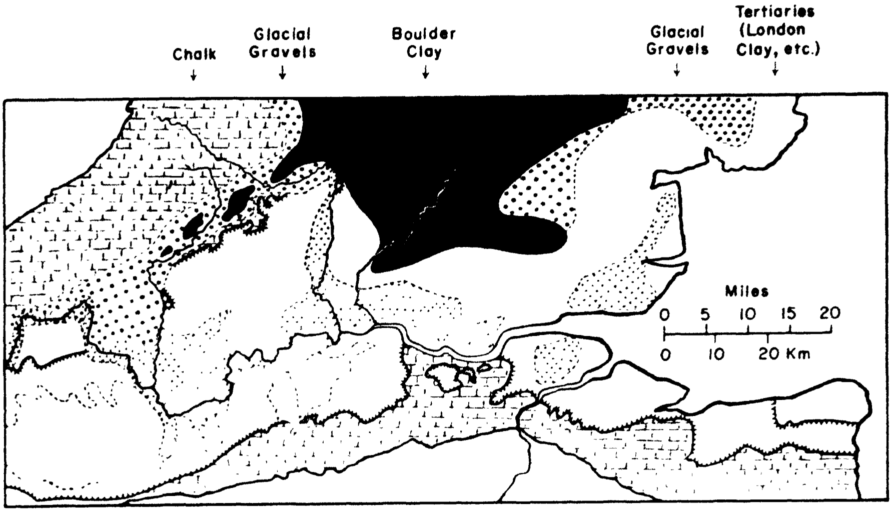



FIG. 40. The geology of the London Basin (simplified)
Lightly dotted area = river gravels; for alluvium, see dotted area on Fig. 41. *After S. W. Wooldridge*

analogues in South Wales or northern France, is highly folded and fractured. It is probable that renewed movements along the folds and fractures of the Paleozoic platform have been responsible for the existence in the London Basin of minor structures. The London Basin, a syncline as a whole, is not symmetrical. Its axis is towards the southern edge, and it is to be noted that it is along this line that the lower River Thames flows. Then there is quite an important fold in the centre with an east–west trend, sometimes known as the Thames Basin or the London Basin Anticline. These minor structures, combined with the very varied character of the

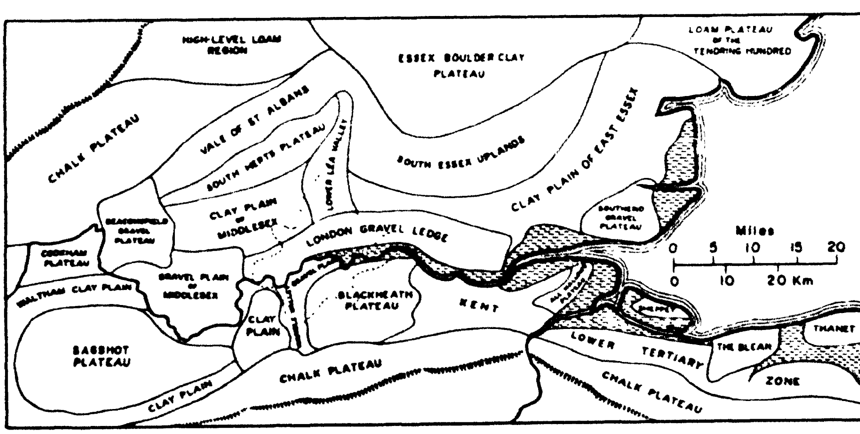



FIG. 41. The minor physiographic regions of the London Basin, according to the late Professor S. W. Wooldridge

young sedimentary rocks which fill in the basin, are responsible for its very varied morphological character. It has, accordingly, been divided into minor natural regions, mainly on a geomorphological basis, by Professor S. W. Wooldridge.[1] Two maps are here reproduced from Professor Wooldridge's account, the one showing the position of the main drift deposits, and the other a suggested regional subdivision of the basin. These two maps must be left to speak for themselves. They should be used when studying in detail the position of London itself.

## The Hampshire Basin

In many ways the Hampshire Basin resembles the London Basin. There is a surrounding girdle of chalk downs and a central region of later clays and sands. Instead, however, of the basin being open to the sea to the east, its southern chalk rim has been cut through by the sea in two places at each

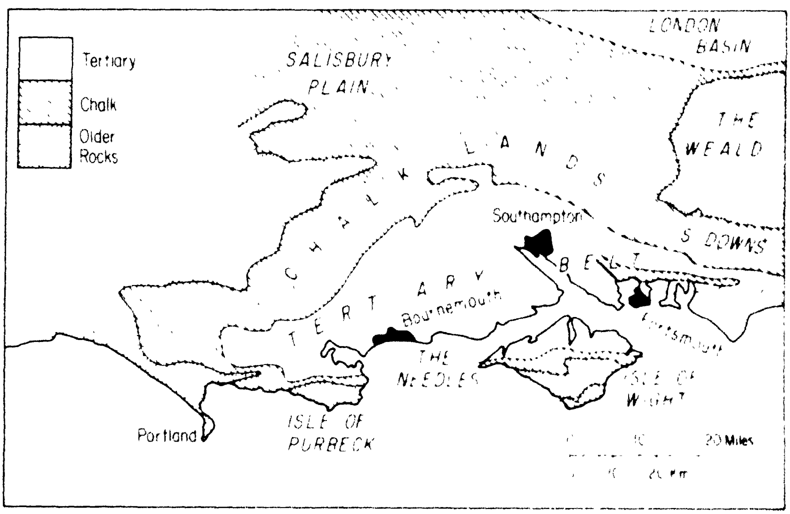



FIG. 42. The Hampshire Basin

end of the Isle of Wight. Although strictly speaking the Hampshire Basin might be limited to the central area of Tertiary rocks, it is convenient to consider the surrounding area of chalk downs also in any general geographical consideration of the Basin. There is thus the Tertiary belt of the heart of the basin, and the surrounding chalk lands. As in the case of the London Basin, subsidiary folds occur, and one important one brings up the chalk to form the Portsdown Hill to the north of Portsmouth (see Fig. 42). The Tertiary belt differs from that of the London Basin in the rather larger proportion of coarse or mixed sands. These are especially important

1. 'The physiographic evolution of the London Basin', *Geography*, **17**, 1932, 99 116.

in the southwest, where the New Forest is found on sandy areas of this character. The more varied of the Tertiary rocks give rise to sandy and loamy soils suitable for mixed farming, and have a low but varied relief. The southern rim of the Hampshire Basin is formed by a sharp fold of chalk which cuts across the Isle of Wight, following its longer axis. To the south of this central ridge in the Isle of Wight there are early Cretaceous rocks, giving rise to varied country repeating on a small scale some of the features of the Weald. In the so-called Isle of Purbeck still older rocks appear, and one sees part of the Jurassic sequence of the Jurassic scarplands.

## East Anglia

East Anglia corresponds roughly with the counties of Norfolk and Suffolk. Chalk underlies most of the western two-thirds of this tract and later Tertiary rocks the remainder, but the whole tends to be so thickly covered with glacial and other deposits that East Anglia is very far from resembling the well-known chalk downland. At the present day it is difficult to realise the former isolation of East Anglia. It is bounded on the north and east by the sea. To the south it stretched as far as the once thickly forested damp lowlands of Essex; on the west lay the impassable marshes of the Fenlands, and it was only to the southwest that East Anglia could be approached along the comparatively dry route afforded by the chalk country of the East Anglian Heights. Though the former isolation has disappeared, East Anglia remains a remarkable geographical entity. The character of East Anglia varies mainly according to the nature of its surface deposits. The whole is a low plateau with an undulating surface, often indeed almost flat, and in which those towns and villages situated along the river courses tend to be hidden, as, for example, in the case of Norwich. A special feature of interest is that area known as the Broads—wide stretches of shallow water, probably resulting from the excavation of peat—where the rivers have been ponded back by the formation of bars preventing the free flow of their waters to the North Sea. As East Anglia is mainly agricultural, its division into subregions will be considered relative to agriculture.

### IRELAND

The geography and natural regions of Ireland have been reserved for special treatment in connection with agriculture (see Chapter 29), but it may be noted here that its physiographic units connect very closely with those of England and Scotland. In the northwest there are masses of ancient metamorphic rocks which form a continuation of the Highlands of Scotland. In the northeast there is the natural continuation of the Southern Uplands of Scotland. Between the two there should be a western extension of the Midland Valley of Scotland, but this is obscured by the huge spread of lava which makes up the so-called Antrim Plateau, a saucer-shaped

basalt plateau with the large but shallow Lough Neagh in the centre. The Mourne Mountains are formed by a mass of granite intruded into rocks which are a continuation of the Southern Uplands of Scotland. The south-east of Ireland is occupied by the Wexford Uplands and the Wicklow Mountains. Doubtless the Wexford Upland area was formerly continuous with the main mass of Wales with which it is geologically and structurally allied, whereas the Wicklow Mountains represent an enormous mass of granite, the largest in the British Isles. Southwestern Ireland is characterised by a succession of sandstone ridges and limestone valleys. The sandstone is mainly of Old Red Sandstone age, the limestone is the Carboniferous Limestone. The folding is Armorican; the folds are not quite east and west, the general trend being from westsouthwest to eastnortheast. The heart of Ireland is occupied by a great plain – the Central Plain – represented on geological maps as consisting of an enormous mass of Carboniferous Limestone. Through this there appear isolated mountain masses consisting either of older rocks, which appear in the form of anticlinal masses from beneath the limestone, or which represent the remnants of younger rocks of Coal Measure age. Actually the Carboniferous Limestone in the heart of Ireland is very rarely seen. It has been covered to a great depth, either by a mask of bog and peat or by sands, clays, and other deposits which were left behind during the retreat of the great ice sheet.

# 4
# British weather and climate

The variability of British weather has long been a byword and, as every holiday-maker knows, the most reliable of British weather experts are apt to be misled, at least at times, in their attempts to forecast the coming weather. Until recently atmospheric conditions at or near the surface of the earth were those which most concerned its human inhabitants. With the coming of the airplane the conditions in the higher layers of the earth's atmosphere suddenly became of considerable importance. It was during the First World War that innumerable investigations had almost perforce to be carried out in the higher layers of the atmosphere in studying the behaviour of air currents and the occurrence of air pockets. It was largely as a result of these investigations, previously of interest mainly to the scientific meteorologist, that ideas concerning the causation of weather conditions were fundamentally changed. The dogmatic statements of the earlier text-books can no longer be accepted, but at the same time it is not yet possible to state fully in simple terms, or with general assurance, the results of modern studies.

The old concept of the planetary wind systems placed the British Isles in the belt of the 'Southwest anti-trades', later described more accurately as the Westerlies or Variables. The development of the Polar Front hypothesis associated especially with the name of Bjerknes and his colleagues of the Norwegian school of meteorologists led to the current concepts of air masses of differing origin and the phenomena associated with the fronts along which these air masses meet. The development of radar led to entirely new knowledge of the character of the upper atmosphere, and this has been greatly extended by the use of space-craft.

Nevertheless, we can still state simply that a number of factors have a determining influence on the character of British weather and climate. The factors may be grouped as follows:

(*a*) The shores of the British Isles, more especially the western shores, are bathed by a warm drift of water, the North Atlantic Drift, which is a continuation of the Gulf Stream. The existence of this warm drift of water has undoubtedly an important effect in ameliorating winter conditions. To the north and northeast of the British Isles no land barrier exists to prevent the flow of water. It therefore makes its influence felt right along the coast of

Norway to well within the Arctic Circle, with the result that even the Murmansk coast of northern Russia remains free from ice throughout the winter. The British Isles thus lie within the winter gulf of warmth and possess a milder climate than any other region in corresponding latitudes. They afford a remarkable contrast in this respect to lands such as northern Japan or Labrador, which are situated on the eastern side of continental masses, and which are under the influence of cold ocean currents. It must be remembered that the direct effect of the warm waters themselves is much less important than the warmth which is communicated from the water to the prevalent southwesterly winds. The existence of the Continental Shelf round Britain enhances the influence of the waters in that they are spread out over a wide area and thus exert a maximum influence in warming the overlying air.

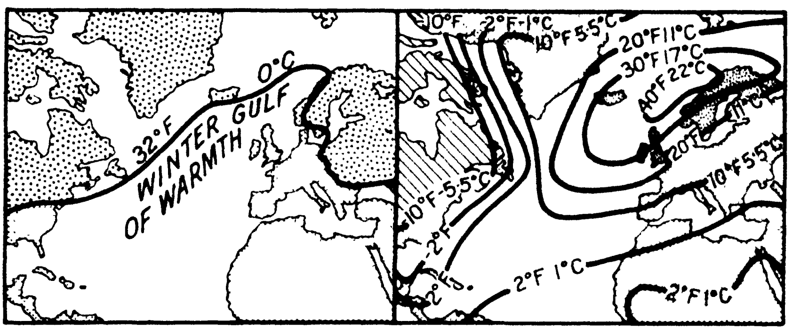



FIG. 43. The figure on the left shows the 'winter gulf of warmth' in which the British Isles lie. The isotherm shown is that of freezing point for January. The figure on the right expresses the same facts in terms of isanomalous lines. All parts heavily stippled are more than 20 Fahrenheit degrees or eleven Centigrade degrees above the average for their latitude. Note the negative anomalies over eastern Canada

(*b*) Except perhaps for certain periods in winter the British Isles lie wholly within what has long been called the westerly wind belt. There is not, of course, at any season of the year a constant westerly or southwesterly wind, although the southwesterly is the *dominant* wind in these islands. What is perhaps more important is the fact that the greater part of our weather comes from the west, that is from across the Atlantic, and that these islands are greatly affected by what are now described as maritime tropical (mT) air masses. The sequence of British weather depends very largely on a series of whirls and eddies in the atmosphere (to which we give the name depressions, or 'lows') and intervening wedges of high pressure which move across these islands in a direction which is generally from between southwest and northwest. By comparing the daily weather maps published by the Meteorological Office for successive days, it is often possible to trace the movements of the individual depressions across the Atlantic Ocean. On the other hand, any long range forecasting based on the weather experienced

on the other side of the Atlantic is obviously liable to go wrong, since the depressions may become filled up and disappear in the course of their passage across the Atlantic or their path may lie to the north or to the south of the British Isles. The sequence of weather during the passage of a depression is well known, but changes in the rate of progression and in the intensity of depressions present considerable difficulties to the forecaster. Further reference will be made later to the character and causation of these depressions.

(*c*) The configuration of the British Isles, particularly the existence of numerous inlets, so that no part of the country is far from the sea, makes the penetration inland of oceanic influences more than would otherwise be the case. The existence of the principal hill masses of Britain on the western side of the islands, combined with the fact that the main rain-bearing winds blow from the southwest, results in a very marked difference in the amount of rainfall on the west and on the east. If it were not for this surface relief the whole of the British Isles would experience a moist climate, more like that of Ireland.

It will now be clear that the passage of depressions, or cyclones,[1] over these islands has a dominating influence in determining the character of our daily weather. Thus the causation of these whirls in the air is a matter of some importance. According to the Polar Front hypothesis first developed by the Norwegian school a very important difference is found between cold polar air and warm air moving from the southwest, that is from tropical and subtropical regions. The position and the amount of the cold polar air varies with the seasons, and this mass of cold heavy air may be regarded as having a front, or southern limit, known as the Polar Front, lying normally somewhere to the north of the British Isles, not infrequently at least in the neighbourhood of Iceland. It has been suggested that in winter the Polar Front may be regarded *very roughly* as following the 0°C (32°F) isotherm. It is the meeting of the current of tropical warm air and the cold polar air that is believed to give rise to the succession of depressions which we associate with the Polar Front. The formation of depressions on this hypothesis is best understood by reference to the diagram. It will be seen that a whirling motion of the air is set up in which the winds blow round a centre, actually a low-pressure centre, in a counterclockwise direction. Where the warm moisture-laden air meets the cold polar air condensation takes place, especially as the warm air rises naturally over the cold air. The indraught of cold air from the north which marks the passing of the depression is accompanied by a drop in temperature, but, after an initial cloudiness explained in Fig. 49, by a clearing of the sky. If one accepts this explanation of the formation of depressions, the fact that the Polar Front is approximately over Iceland would result in a continuous succession of depressions passing

1. It has now become more usual to restrict the term 'cyclone' to tropical storms.

across Iceland in a northeasterly direction. If one takes an average of such conditions one gets the conception of a semipermanent low-pressure system situated approximately off Iceland.

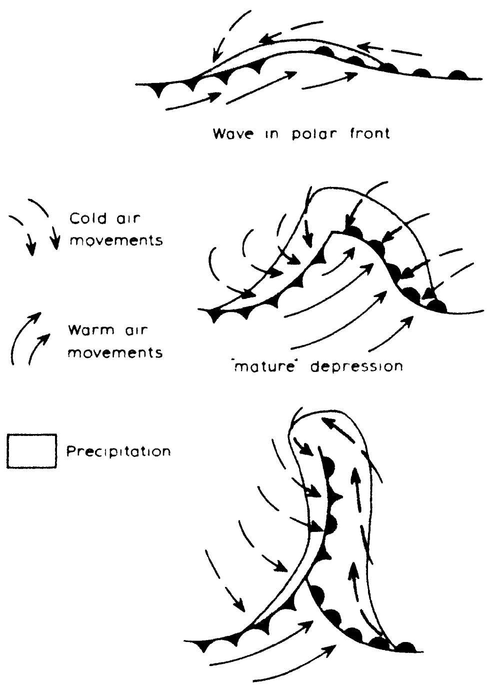



Fig. 44. Diagram illustrating the Polar Front hypothesis of the formation of depressions

## Weather and climate of northwest Europe

Before considering the weather conditions in the British Isles in particular, it will be necessary to look at the weather conditions affecting the whole of Europe, and it is simplest to do this by contrasting the winter and the summer conditions.

### Winter conditions

In the winter months the Continent of Europe lies in the belt of westerly winds, warm moisture-laden winds from the Atlantic Ocean. The extra-tropical belt of high pressure at this season lies well to the south of the Continent—over the Sahara and its continuation into the Atlantic Ocean to the south of the Azores. Thus there is a high pressure area over the Azores and, as we have already seen, a semipermanent low pressure system roughly over Iceland. But the eastern part of the Continent is very near the great land mass of central Asia, of which it is indeed a continuation, and so at

this season gets extremely cold. One may picture a great mass of cold heavy air over Asia and eastern Europe, giving rise to a permanent high pressure system in the winter. The warm moisture-laden air from the Atlantic blows up against this, as against a wall, and either finds a way of escape to the northeast along the coast of Norway, or a way of escape to the south along the Mediterranean. At times this great high pressure system of eastern Europe, with its cold outblowing winds, may exert its influence even as far as the British Isles and may therefore give rise to cold and frosty, though often sunny, weather. Indeed it may be said that the winter weather of the British Isles is determined by the relative strength or importance of

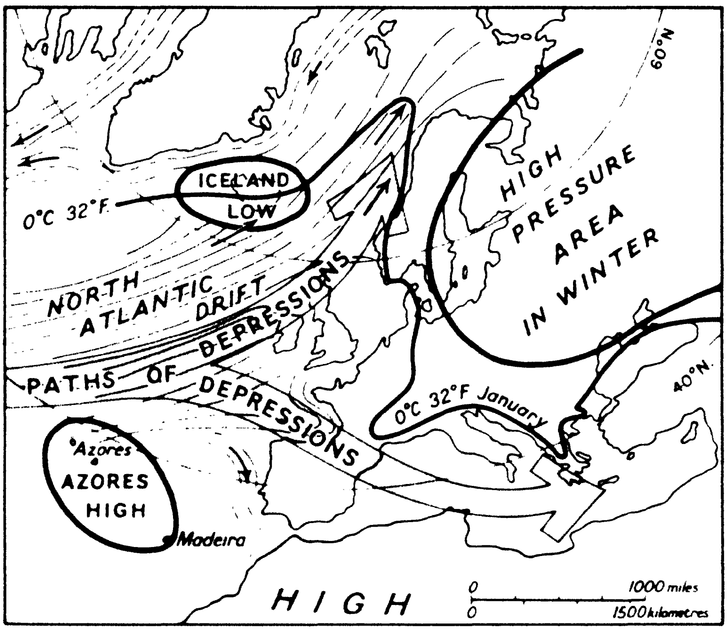



FIG. 45. Generalised winter conditions

Many of the depressions moving along the southern path do not, in fact, penetrate farther than Italy

these three great pressure systems—the semipermanent low pressure system over Iceland, the permanent high pressure system over eastern Europe, and the high pressure system south of the Azores. Bearing these facts in mind it is not difficult to understand why in the winter months it becomes steadily colder as one travels eastwards across the British Isles and, indeed, as one travels eastwards in Europe. In Europe the isotherm of 0°C (32°F), or freezing point, divides the Continent roughly into two halves and, as we have already noted above, we may look upon this isotherm as marking approximately the position at this season of the Polar Front. Thus the cold mass of air over Russia and eastern Europe may be regarded as lying within the Polar Front. At this season the moisture-laden winds from the west

deposit their moisture on the western sides of the land masses; they are unable to penetrate very far towards the east and so there is comparatively little precipitation in the east. This is apparent even in the British Isles, where in the western half of the islands more than half of the total rainfall comes in the winter months, whereas in the eastern half of the islands the greater rainfall is during the summer months (see Fig. 59).

## Summer conditions

At this season the wind systems of the world have moved to the north of their average position, so that only the northern part of Europe comes under the influence of the westerly winds. The southern parts of Europe, that is to say the countries surrounding the Mediterranean Sea, lie within the influence of the high pressure belt which almost girdles the globe just outside

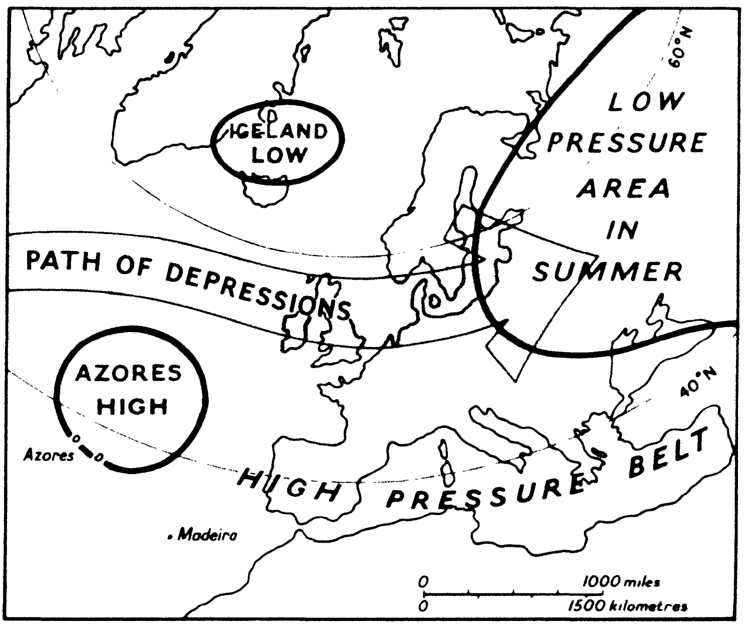



FIG. 46. Generalised summer conditions
The main depression path might more justifiably be shown north of the British Isles

the Tropics. The high pressure reigning in the summer months over the Mediterranean prevents the penetration of the cooling, or rain-bearing, winds from the Atlantic Ocean. Consequently the Mediterranean lands suffer from considerable heat and comparative, or even complete, rainlessness. In the Atlantic the high pressure centre of the Azores, which forms part of this belt of high pressure, is north of its winter position and frequently extends its influence as far as the British Isles. On the other hand the Polar Front is farther to the north and the belt of depressions which is

associated with it tends to be rather north of the island of Iceland and to affect the British Isles far less than in the winter. In eastern Europe the conditions of winter are reversed. The great continental land mass is greatly heated and a large low-pressure area is the result. There is a tendency for the low pressure to be particularly marked over southern Russia; towards this area the rain-bearing winds from the Atlantic blow, and result in the light spring rains of the steppelands of southeastern Europe. Thus central and eastern Europe have the greater part of their rain, that is to say more than half the annual total, in the summer half of the year rather than in the winter.

It needs but a glance at a map of Europe to realise that the British Isles tend to be centrally situated between the three main pressure systems, and actually our weather, both in winter and summer, is largely determined by their relative strength. In winter there is a distinct tendency for the low pressure system over Iceland to be the most potent in determining the weather of these islands, except in those years when the high pressure system over eastern Europe is exceptionally strong and extends its influence as far as the east coasts of Scotland and England. For example, in the winter of 1928–29, and again in 1939–40, 1946–47 and 1962–63, when settled cold weather prevailed for long periods at a time, with cold easterly or north-easterly winds, it was found that the pressure system of eastern Europe was extending its influence as far as these islands. It should be noticed that when one of the high-pressure systems extends its influence in this way there is a distinct tendency for the weather to remain settled for considerable periods of time. Thus in summer, when the high pressure system of the Azores stretches rather north of its normal position, there is a possibility that at least the south of England will enjoy long spells of fine weather. This happened in the summer of 1921,[1] again in 1929, in 1931, 1947 and 1959. These summers were marked, during the months of August and September, by fine and hot weather over the whole of the southern three-quarters of the islands; but in 1929 in particular the summer was marked in northern Scotland by an extended period of bad weather: in other words, the path of the depressions from the Atlantic lay along the northern fringe of the high pressure system which remained comparatively stable over southern Britain. On the other hand, there are years like 1968, in which the depression tracks in August lay across southern England, giving that area an extremely cool and wet holiday season, while northwest Scotland basked in the unaccustomed sunshine of its finest summer for several decades.

So far we have considered only the three great pressure systems which are dominant factors in determining European weather, but actually the weather in these islands is determined to an even greater extent by the passage of a succession of secondary depressions with intervening ridges of high pressure. Since the British Isles are intermediately placed between the

1. *Q. Jour. Roy. Met. Soc.*, **48**, 1922, 139–68 (dealing with droughts in general).

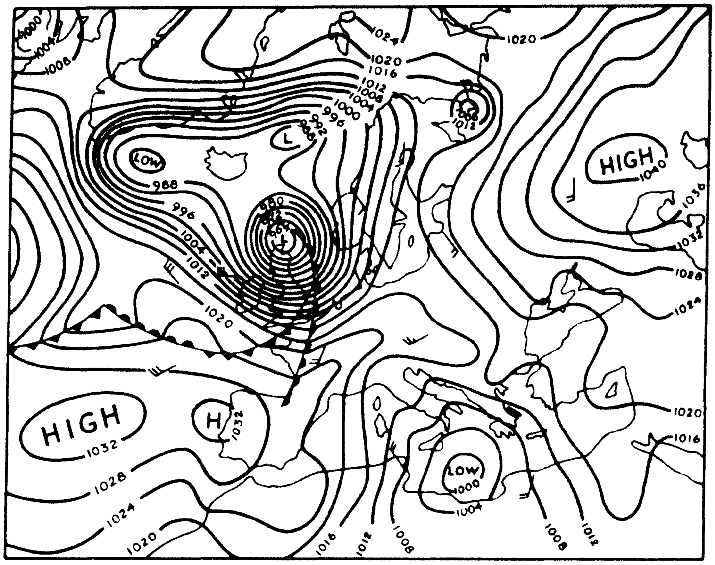



FIG. 47. Weather conditions on Sunday, 30 December 1951

This weather chart shows typical winter conditions with a high pressure system over eastern Europe, a 'high' over or near the Azores, and a low pressure area, with several centres, between Scotland, Iceland and Greenland. Such a situation, with warm and cold or occluded fronts, passing across the British Isles, gives the characteristically variable weather of the British winter. A characteristic small depression is passing over the Mediterranean. Isobars are shown with values expressed in millibars.

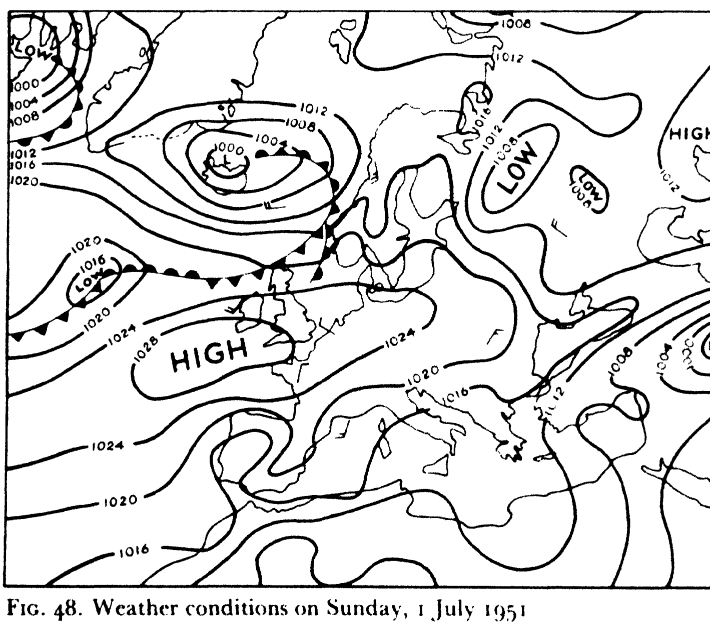



FIG. 48. Weather conditions on Sunday, 1 July 1951

This weather chart shows typical summer conditions, with low pressure systems over Iceland and eastern England and a 'high' extending from the Azores to Britain. The 'polar front' lies for the most part to the north of the British Isles, which are bathed in mT air. But in many summers the fronts frequently pass farther south so that rain and incursions of mP air are common.

three great pressure systems of Europe both in summer and in winter, it follows that the line of passage of these secondary depressions must lie across these islands in both seasons of the year. Since this is the case it is desirable to examine in a little more detail the succession of weather which results. One must remember that a depression in the northern hemisphere is marked by a low-pressure centre with upward currents of air. Winds tend to blow round this centre, for reasons which have already been explained, in an anticlockwise direction, and at the same time towards the centre, where they rise. When a depression is approaching these islands from the Atlantic the barometer will fall and winds will be southerly to southwesterly,

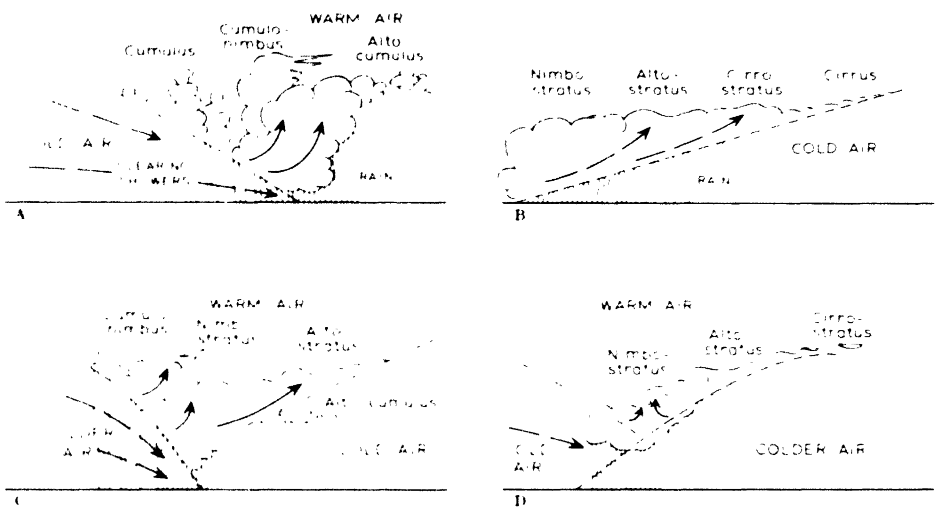



FIG. 19 Sections through typical depressions. A and B: the cold front and warm front as usually developed south of the centre of low pressure; C: a 'cold' occlusion; D: a 'warm' occlusion

veering westerly later. Coming from the Atlantic, they will be warm and moisture-laden, blowing northwards towards cooler regions and also towards the central depression where they will rise, so that rain begins to fall. Where the oncoming warm southwesterly winds meet the colder air, the 'warm front', as it is called, is formed, and along this warm front, where the air is cooled by rising over the cold air, rain is likely to occur, and prolonged steady rain may result. Subsequently there is usually a break in the weather. After the centre of the depression has passed across the islands, usually in an easterly, or northeasterly, direction, the barometer will again rise and the normal air currents will now be the colder winds from the north or northwest. These winds are comparatively dry, but where they impinge on the flanks of the southwesterly current intense rain with squalls may result. This is shown in the diagram as the 'cold front'. Of course the

exact sequence of weather at any locality depends on its position in relation to the centre of the depression. If the centre passes to the north of the locality, both warm and cold fronts, with the intervening warm sector, may be experienced; but if it passes to the south, no fronts will cross and there may simply be a prolonged rainy period with the wind gradually backing from east to northwest. The passage of such a depression is often, one might say usually, followed by the passage of a ridge of high pressure, ushered in by the continuation of the cold northerly winds and a steadily rising barometer. Fine sunny weather may result in the summer, but as the winds decrease and calm conditions prevail the passage of such a ridge of high pressure is often marred in winter by the occurrence of fogs.

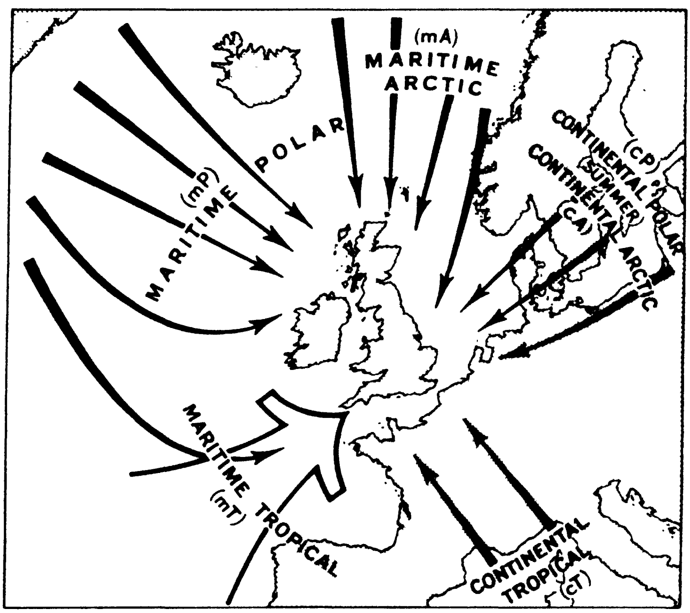



FIG. 50. Diagram showing origin of air masses reaching Britain

Compare with Figs 45 and 46

The large generalised arrow for mT air is not intended to indicate that this is more important than mP air

## Air masses reaching the British Isles

It is now possible to restate what has been said in the last few pages in modern terms by stating that the British Isles are affected by six principal types of air or air masses. Most of the air reaching Britain can be traced to one of four main source regions—regions where the air has had sufficient time, such as a number of days, to acquire a degree of homogeneity of temperature, humidity and vertical structure throughout its mass. These four source regions are the northern (and especially the northwestern) Atlantic, the Arctic, eastern or continental Europe, and the middle Atlantic

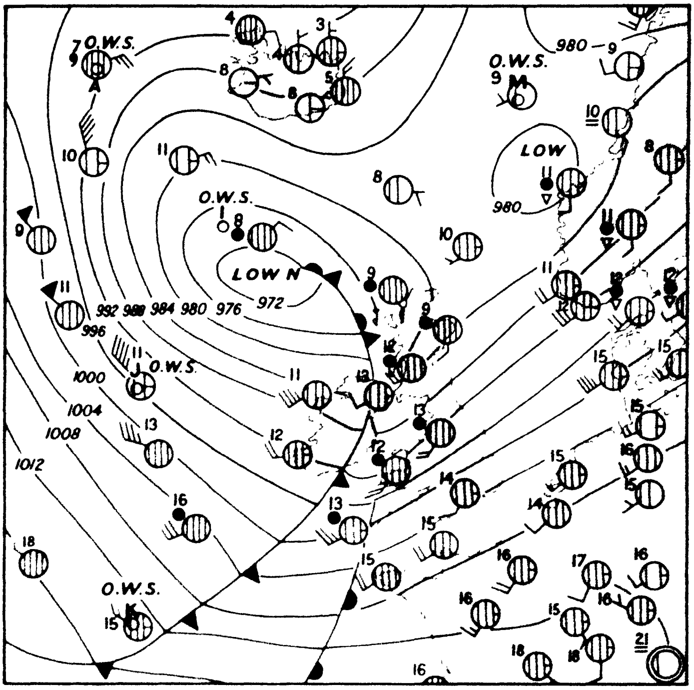



FIG. 51*a*. A typical depression: for key to symbols see Fig. 51*b*

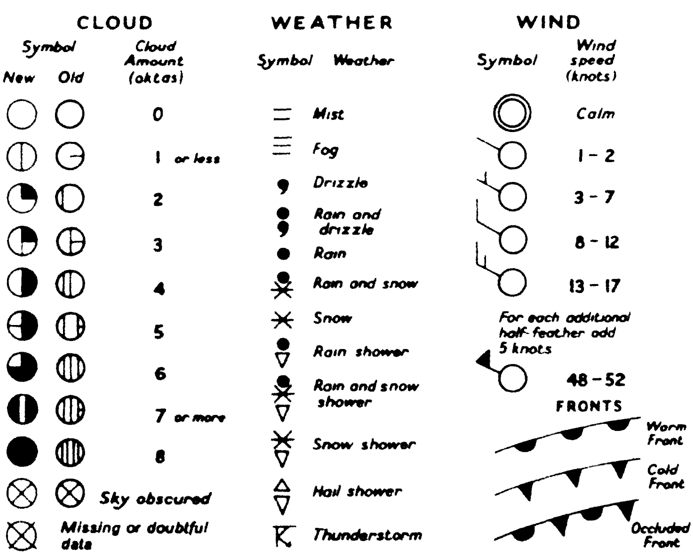



FIG. 51*b*. Symbols used on the Daily Weather Reports. The *cloud* symbols were changed on 1 January 1969 and are shown in the left hand column

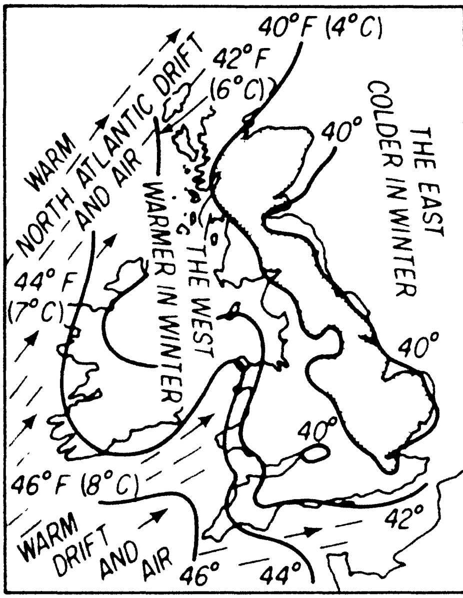
high-pressure area of the Azores. The north Atlantic yields the air streams that are called Polar maritime (mP); these are damp and unstable, with a high lapse rate that is increased as they move southwards into warmer latitudes. The Arctic (mA) air masses originate over the polar ice cap and move southwards from the region of Spitzbergen; they seldom occur except in winter, and are bitterly cold, and also somewhat damp and unstable. Polar continental (cP) air masses originate over eastern Europe; in winter, especially if they are drawn from northern Russia, they are very cold and dry; they are less common in summer, but when they do occur, generally under anticyclonic conditions, they are also dry. The mid-Atlantic area of the Azores yields maritime Tropical (mT) air masses, warm, damp, and relatively stable, though capable of giving much rainfall when forced to rise over relief obstacles or over cold polar air masses. Continental Tropical (cT) air masses, derived from northern Africa and the Mediterranean area, are dry and very warm; they occur but rarely in summer, and are virtually unknown in winter.

## The equinoxes

In the analysis of the general conditions in Europe we referred to the formation of a great high pressure centre over eastern Europe in winter and the formation of a low pressure centre over the same area in summer. Naturally there must be two seasons of the year when the change from one to the other takes place, and it is very largely the resulting disturbance of atmospheric conditions which is responsible for the well known equinoctial gales experienced in this country. Whilst in the early part of the year high winds are associated with the month of March and the fame of March winds is perpetuated in many a nursery rhyme and popular ballad, the change indicated by these winds does not always take place at exactly the same time. In some years March may 'come in like the lion and go out like the lamb', in others it may come in like the lamb when the winter conditions still prevail, but go out like the lion. The corresponding high winds associated with the disturbances at the autumnal equinox are the equinoctial gales of September and October. After the equinoctial gales of March come the still unsettled conditions of April, when numerous small secondary disturbances in the unstable polar maritime air streams result in April showers. The small rainfall of the early spring months can be correlated with the small evaporation. Indeed, evaporation is almost confined to the six months of April to September. There is a definite lag between the increase of evaporation in April and the increase in the mean rainfall per rain day which does not exceed the average for the year until July. Similarly the mean rainfall per rain day continues above the average for the year for some three months after the evaporation has practically ceased at the end of September.

## Temperatures

So far we have been dealing with the weather conditions of the British Isles, and owing to the irregular succession of weather it is sometimes said that the British Isles have no climate, since climate is described as the average state of the weather. This may at least serve as a useful reminder that we should use averages with care owing to the variability from year to year. Taking, first, temperature conditions in the winter, it may be said that in



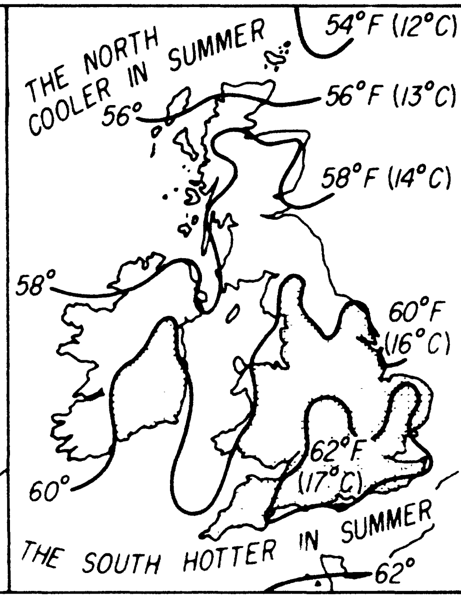




Fig. 52. Temperature conditions in January 1906–35

Fig. 53. Temperature conditions in July 1906–35

Mean temperatures reduced to sea-level (after E. G. Bilham)

general conditions in the British Isles reflect in detail those prevailing in Europe as a whole. In winter the west is warmer than the east and the isotherm of 14°C (40°F) in January roughly divides the islands into two. Its curve should be carefully noted. As one would expect at this season, the extreme southwest of Britain and southwestern Ireland are, taking the average conditions in January, the warmest parts of the islands. The Scilly Isles have an average temperature in January of no less than 7°C (45°F), whilst snow and frost are both rare. The important effects which this has on the products which are possible in these areas, and on the use of warmer parts of Britain in winter as winter resorts, may be mentioned. Taking the evidence afforded by the isotherms alone the coldest parts in the British Isles in winter are certain tracts down the east coast, and it would seem that the east coast of Scotland in the neighbourhood of Aberdeen is not as cold as some parts of the coast of East Anglia farther south, but the ordinary dry-

bulb thermometer is scarcely an adequate measure of temperature in so far as it affects human beings and there is perhaps a rawer quality in the air in northern tracts. In summer, by way of contrast, the south of the British Isles is warmer than the north. The isotherm of 15.5°C (60°F) in July runs roughly from east to west. The southeast quarter is the warmest of all in

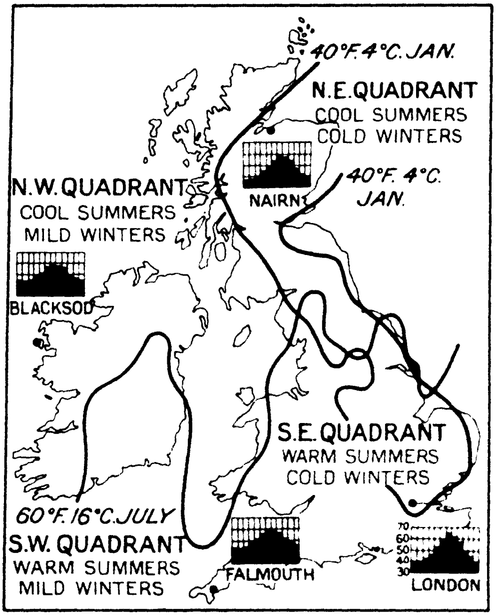



FIG. 54. The four quadrants of the British Isles

July in the neighbourhood of London, but the average along the south coast is high. The coolest parts of the islands at this season of the year are the extreme south of Scotland, the Orkneys and the Shetlands. Though geographers have long been accustomed—perhaps too slavishly—to take January and July as the typical winter and summer months, they are not in the British Isles the coldest and warmest months respectively. It frequently happens in oceanic or insular climates that there is a considerable lag between the period when the sun's rays strike least obliquely or most obliquely on the surface of the ground and the time when the highest and lowest average temperatures are reached, so that for many parts of the British Isles February is the coldest month and usually August the hottest month. Even, however, taking January and July and noticing the course of the isotherms across the islands, it will be seen that the 4°C (40°F) isotherm for January and the 16°C (60°F) isotherm for July divide the islands roughly into four quarters. The northwest quadrant is the most 'oceanic', and it is possible to find stations in the Outer Hebrides which have a range of only 13°–6° (= 7 degrees) C or 56–43 (= 13 degrees) F between the winter months and the summer months. The southeast quadrant is the most nearly 'continental', if that adjective can be applied at all to any part of the British

Isles. Nevertheless, the temperature range of London is from 18°–3°C (64°–38°F)—no less than 15 degrees C (26 degrees F)—quite a remarkable contrast to the stations just mentioned.

So far we have been considering temperature as it affects lowlands, and the isotherms which have been discussed are sea level isotherms. If one considers the actual surface temperatures as recorded the theoretical difference between actual temperature and temperature reduced to sea-level is 0.6°C for every 100 metres (1°F for 300 ft). Since the greater part of Lowland Britain is less than 200 metres (600 ft) above sea level the theoretical difference does not exceed 1.2°C (2°F). Elevation begins to exert an important effect on the higher ground of Highland Britain and on the top of the highest point in the British Isles, Ben Nevis (1341 m: 4400 ft), the temperature if reduced to sea level equivalent would be nearly 8°C (15°F) higher.

The effect of elevation justifies us in regarding the Highlands of Scotland in January as the coldest part of the country. The factor of elevation is readily apparent when snowfall is considered (see Fig. 60). Whilst in the southwest of the country, in Devon and Cornwall, snow does not normally fall on low ground on more than five days in each year, and is not found to be lying for more than five days, such lofty tracts as Dartmoor are frequently seen to have a powdering of snow. Indeed, on the higher parts of Dartmoor snow normally lies for more than twenty days in every year.

The effect of elevation on temperature is however far from simple. Cold air behaves much like cold water. It flows downhill and will collect in a valley or basin where there is no outlet and gives rise to a 'frost pocket' or 'frost hollows'. Some extremely low temperatures have been recorded in such obstructed valley situations amongst the Chiltern Hills. On the other hand, where cold air can drain freely as it does down river valleys and out over the sea, such frost pockets are absent.

Studies which have been undertaken in connection with the growing of fruit and the siting of fruit orchards have shown how very important it is to secure free drainage of air. Even a high hedge can hold up air movement and increase the hazards of frost (see Fig. 58). In addition aspect plays a much greater part in the determination of local climates than was suspected in the past. If one attempts to determine the upper limit of cultivation in such areas as the Pennines, one finds that cultivation is almost invariably to a higher level on the northern sides of valleys, that is to say on those slopes facing southwards towards the sun, than it is on the southern sides of the valleys.

Hills running from east to west afford a remarkable protection from cold northerly or northeasterly winds. The attraction of Ventnor, on the southern side of the Isle of Wight, is very largely due to the protection of the town from northerly winds by the high chalk downs which lie immediately behind. The early cultivation of tomatoes along a strip of the Sussex coast in the neighbourhood of Worthing is in large measure due to the protection

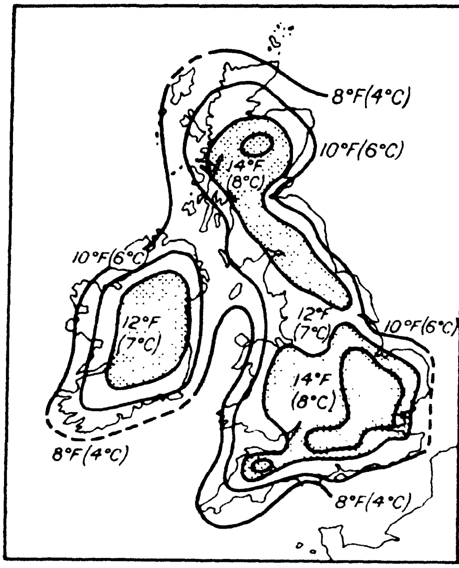



Fig. 55. Mean daily range of temperature (whole year), 1906–35

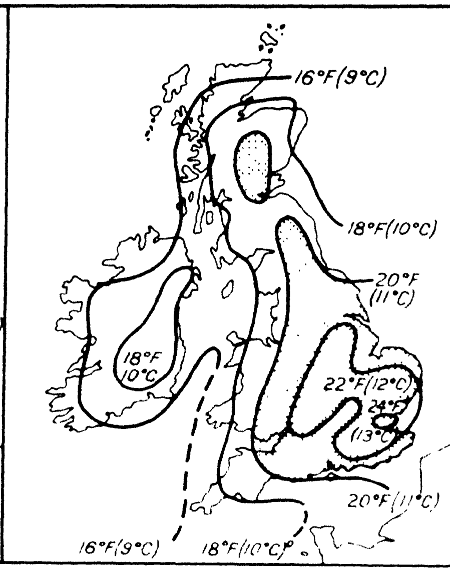



Fig. 56. Mean annual range of temperature 1921–35

Both these maps are after E. G. Bilham and clearly illustrate the moderating influence of the sea in lowering the range of temperature both diurnal and annual, whilst Fig. 56 illustrates the relative continentality of south-eastern England

afforded by the South Downs in the immediate hinterland. The delightful mildness of Aberystwyth, which is important to the town as a resort, is again partly due to the protection by the Welsh hills behind. By way of contrast some of these sheltered resorts are described as enervating by those who prefer the more bracing conditions from the vigorous winds of the east coast in the winter. This brings us to a consideration of the very important question of frost. The following table shows the normal number of days when ground frost occurs at some widely scattered stations in Britain:

*Normal number of days with ground frost*

| STATION | METRES | HEIGHT FEET | J | F | M | A | M | J | J | A | S | O | N | D | TOTAL FOR YEAR | DAYS WITH SNOW |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Balmoral | 283 | 930 | 23 | 21 | 21 | 17 | 9 | 3 | 2 | 1 | 5 | 10 | 18 | 21 | 151 | 50 |
| Glasgow | 55 | 180 | 12 | 10 | 11 | 8 | 3 | 1 | 0 | 0 | 4 | 8 | 10 | 12 | 79 | 16 |
| Birmingham | 163 | 535 | 17 | 15 | 15 | 11 | 5 | 1 | 0 | 1 | 3 | 7 | 14 | 13 | 102 | 11 |
| London | 3 | 18 | 15 | 15 | 15 | 13 | 4 | 1 | 0 | 0 | 2 | 8 | 14 | 14 | 101 | 13 |
| Clacton | 15 | 54 | 12 | 13 | 11 | 7 | 1 | 0 | 0 | 0 | 0 | 1 | 7 | 9 | 61 | 16 |
| Liverpool | 57 | 188 | 14 | 14 | 18 | 9 | 1 | 0 | 0 | 0 | 0 | 1 | 10 | 13 | 80 | 11 |
| Falmouth | 51 | 167 | 8 | 8 | 10 | 5 | 0 | 0 | 0 | 0 | 0 | 1 | 6 | 9 | 47 | 5 |
| Guernsey | 90 | 295 | 6 | 6 | 5 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 4 | 27 | |

A distinction is made between days on which snow is seen to fall (given in this table) and days with snow lying (Fig. 60).

Late frosts in spring are particularly dangerous in such enterprises as fruit farming. They may occur after blossoming and affect the young fruit before it has had time to grow large enough to resist damage. There are many plants which are killed by the first frost of the autumn, e.g. soft-stemmed plants like the vegetable marrow, or flowers such as nasturtium. It is the shortness of the growing season between the last killing frost of spring and the first of autumn, as well as the absence of really high summer temperatures which prohibit the cultivation in the British Isles on a farm scale of such a crop as maize.

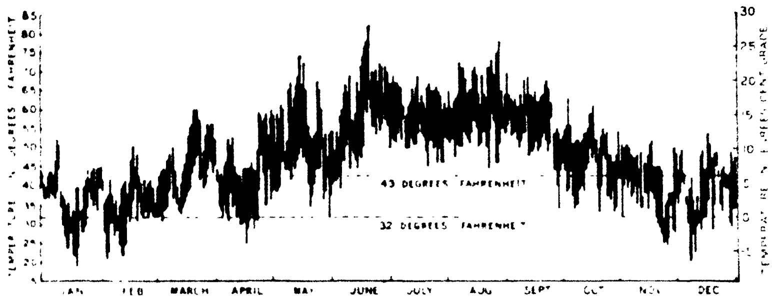



FIG. 57 Diagram showing the temperature range for each day in a typical year (1936) at Macclesfield, Cheshire, 152 metres (500 feet) above sea-level

Notice the number of days when the temperature exceeded 6°C (43°F) the crucial temperature for plant growth. By adding together the number of degrees shown in this diagram above 43°F one gets the concept of accumulated temperature expressed in day degrees

Another crucial temperature is 6°C (42 or 43°F). At temperatures below this figure most plants are dormant and vegetative growth takes place only when temperatures rise above this figure. This factor is important where fodder grasses are concerned. Since the average temperatures for the coldest month are above this crucial figure in the southwest of England some vegetative growth is going on even in the coldest month, and stock left out in the open can find at least some sustenance in new growth which may be rare or completely absent in colder eastern regions.

Most of the preceding references have been to average temperatures. Considerable importance must be attached to temperature ranges both daily and annual. The two figures (Fig. 55 and Fig. 56) show how the mean daily range throughout the year increases steadily inland from the coasts. This is in some contrast to the mean annual range of temperature which is actually greatest near the southeast coast, and least over the windy islands of northwest Scotland.

Considerable importance must also be attached to absolute maxima and absolute minima, especially the latter. A maximum temperature during the day exceeding 32°C (90°F) in the shade is not infrequently recorded at many stations. Records of 38°C (100°F) and over are extremely rare but have been recorded. For long it was doubted whether a temperature as low

as $-17°C$ (0°F) had ever been recorded. Any doubt, however, regarding the possible occurrence of such low temperatures in the British Isles was removed once and for all during the long cold spells of the winters of 1939–1940, 1946–47 and 1962–63 when temperatures down to $-20°C$ ($-4°F$) were officially recorded. Though very rare such very low temperatures were found to have an unexpected importance. Many plants normally hardy failed to survive and a good example was the widespread destruction of the Californian *Cupressus macrocarpa*. Trees of this species which had flourished for ten to fifteen years were killed by the very low temperatures, probably because the low temperatures were maintained for several days.

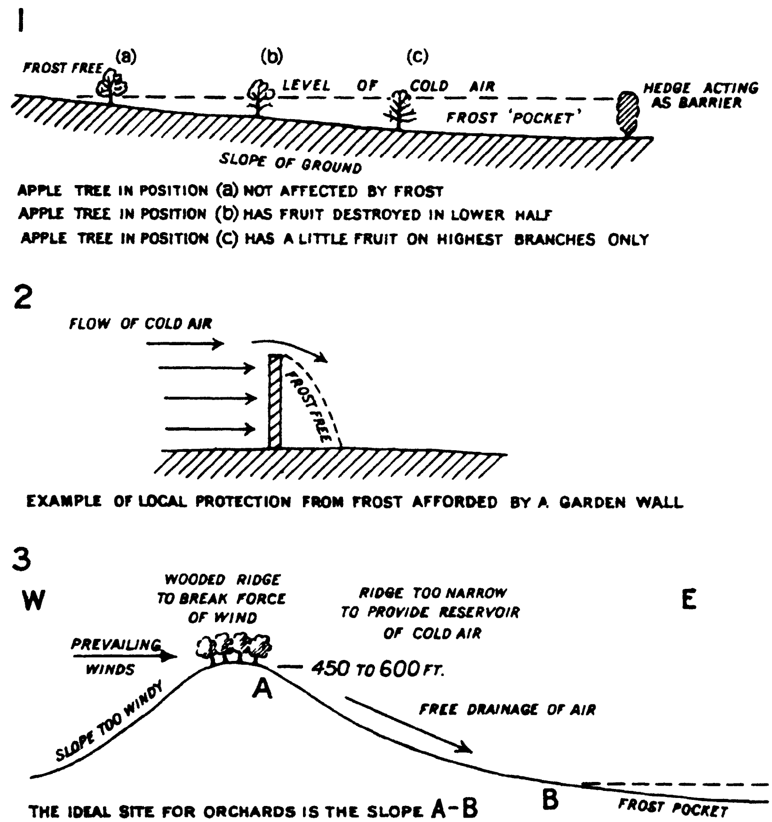



FIG. 58. Diagrams showing the relationship of air drainage to frost pockets and frost-free slopes

## Precipitation

In the British Isles precipitation includes drizzle, rain, sleet or hail, and snow, which fall on to the surface of the ground, whilst moisture may also be precipitated from the air as dew and hoar frost or rime, which are directly

deposited on exposed surfaces. The distinction between drizzle and rain is now commonly made on the basis that a drizzle drop, from 0.3 millimetres to 0.25 millimetres (one-eightieth to one-hundredth of an inch) in diameter, is only one-quarter to one-twentieth of the size of a raindrop. Whereas raindrops usually fall, drizzle is drifted by the wind.

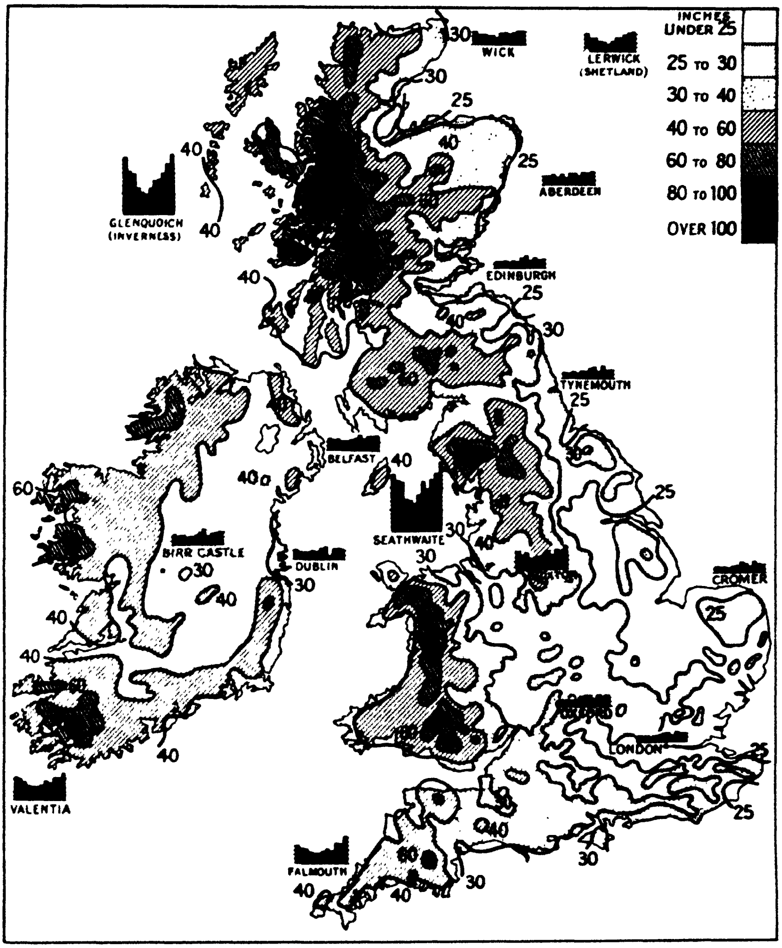



FIG. 59. An annual rainfall map of the British Isles

With the steady accumulation of data, refinements and changes in such a map are possible. For a detailed modern map of Great Britain that in the National Planning Series on the scale of 1:625,000 (in two sheets, Ordnance Survey, second edition, 1968) should be used.

The measurement of moisture deposited as dew or hoar frost is difficult and its influence on vegetation is imperfectly understood. The other forms of precipitation are usually reduced to rainfall equivalent and the remarks which follow regarding rainfall distribution must be taken as including also these other forms of precipitation. A map has been prepared showing the

average annual rainfall of the British Isles, together with rainfall graphs showing the distribution of rainfall in the different months of the year. These indicate certain important points: the first is the well distributed rainfall throughout the year, characteristic of the British Isles; the second is the general tendency for stations on the west to receive the greater part of their precipitation in the winter, while farther east the greater proportion of the rainfall occurs in the summer half of the year. The third is that in general there is an autumn maximum, usually reached in October, extending roughly for the period of the equinoctial gales.

Then the map illustrates quite clearly the general broad distinction between the drier east and the wetter west, with the areas of heaviest rainfall—more than 1500 millimetres (60 in)—on the upland and highland areas, particularly of Scotland, the Lake District, the Pennines, Wales and western Ireland. The average annual rainfall is about 500 millimetres (20 in) in the neighbourhood of the Thames estuary and probably reaches 5000 millimetres (200 in) over small areas in the Western Highlands, at the head of the River Garry and on Snowdon. This suggests at once that the rainfall of the British Isles is mainly orographical, but if it were entirely orographical, then the east, of course, would be much drier than is actually the case. In reality the rainfall of the British Isles is partly orographical due to the relief of the islands—partly frontal and, in a smaller degree, brought by thunderstorms. The relative importance of the different factors causing rainfall will of course vary from place to place, largely in accordance with relief, aspect and exposure. The following figures, for Keele in north Staffordshire, are representative of Midland England: of the total rainfall in the fifteen years 1952–66, 22.6 per cent came from Warm Fronts, 12.4 per cent from Warm Sectors (the tropical air masses between the warm and cold fronts of a normal depression), 14.9 per cent from Cold Fronts, 17.6 per cent from Occlusions, 18.9 per cent from unstable mP air masses, 8.7 per cent from Polar Lows (frontless depressions in polar air streams), 1.7 per cent from Polar Continental and Arctic air masses, and 3.1 per cent from convectional thunderstorms in tropical air masses. Of these, warm-sector rain is largely orographic in character, whilst frontal rain and precipitation from unstable mP air masses are always liable to be accentuated by relief and elevation.[1]

It may be said at once that the rainfall in all parts of the British islands is adequate for agricultural purposes and, in many of the more hilly regions, the rainfall must actually be classed from this point of view as excessive. The coasts of Ireland, western Scotland, and many parts of western England and Wales receive too much moisture to make farming possible or at least profitable. A severe limitation is applied by excessive moisture on crops which can be grown by the arable farmer, and it is not too much to say that farming of all types may be prevented in certain areas. Further considera-

1. See papers by E. M. Shaw referred to on p. 817.


Fig. 60. Snowfall in the British Isles, showing the number of mornings with snow lying, annual average 1912–38 (after Gordon Manley)

(Simplified from the *Meteorological Magazine*, **76**, 1947, by permission of the Controller of H.M. Stationery Office)

tion will be given to this question later, but it may be said that cereal farming, with the exception of the cultivation of that hardy crop, oats, is largely restricted to the regions having less than 760 millimetres (30 in) of rain per year. It has, indeed, been suggested that England can be divided into four agricultural provinces by using the 15.5°C (60°F) July isotherm and the

760 millimetres (30 in) rainfall line, since the 15.5°C (60°F) isotherm marks the approximate northern *economic* limit of the cultivation of certain crops (e.g. wheat).

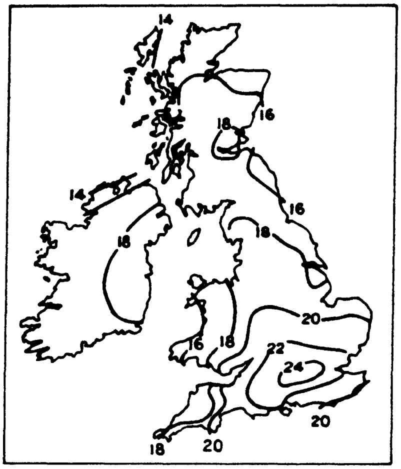



FIG. 61. Evaporation from open water in the British Isles. Average annual amount in inches (after J. Wadsworth)

Rainfall by itself is not, of course, an adequate measure of the relative wetness or dryness of a country from the agricultural point of view, but with cloudy skies and comparatively low temperatures throughout the year evaporation is relatively small;[1] long periods of drought are unknown. Further, the variability of British rainfall from one year to another is comparatively slight; it is rare for any part to experience more than 160 per cent, or less than 50 per cent of the average. There are occasions when the British farmer, robbed of showers of rain at just the seasons when he considers his crops require moisture, complains of drought;[2] but the British Isles may be said never to suffer from drought in the way in which that scourge may affect such an area as Australia. The difference in moisture conditions between the western and eastern sides of Britain is perhaps greater than would appear from an examination of rainfall figures. Since the largest proportion of the rain on the eastern side is cyclonic in character, periods of heavy rain tend to be separated by days when rainfall is practically nil. On the other hand, in the west, particularly in Ireland, there is a much greater

1. Evaporation from exposed water surfaces has recently been shown by J. Wadsworth to vary more than was previously believed—from under 355 millimetres (14 in) per annum in northwest Ireland and northwest Scotland to over 610 millimetres (24 in) in the heart of the London Basin (Fig. 61).

2. He is right; evapotranspiration studies have shown moisture deficiencies in at least some months of the year in the drier parts of Britain in most years and the use of supplemental irrigation for valuable crops such as vegetables is spreading.

tendency for a succession of days of light drizzle. It is a common greeting in Ireland for one farmer to say to another, 'Fine soft day today', meaning a day characterised by warm gentle drizzle. The average number of days with rain increases very steadily from the southeast to the northwest of the British Isles. This is due to the greater frequency of depressions to the north of these islands. Unlike the actual quantity of rainfall, geographical position is of more importance than altitude in determining the number of days with rain.

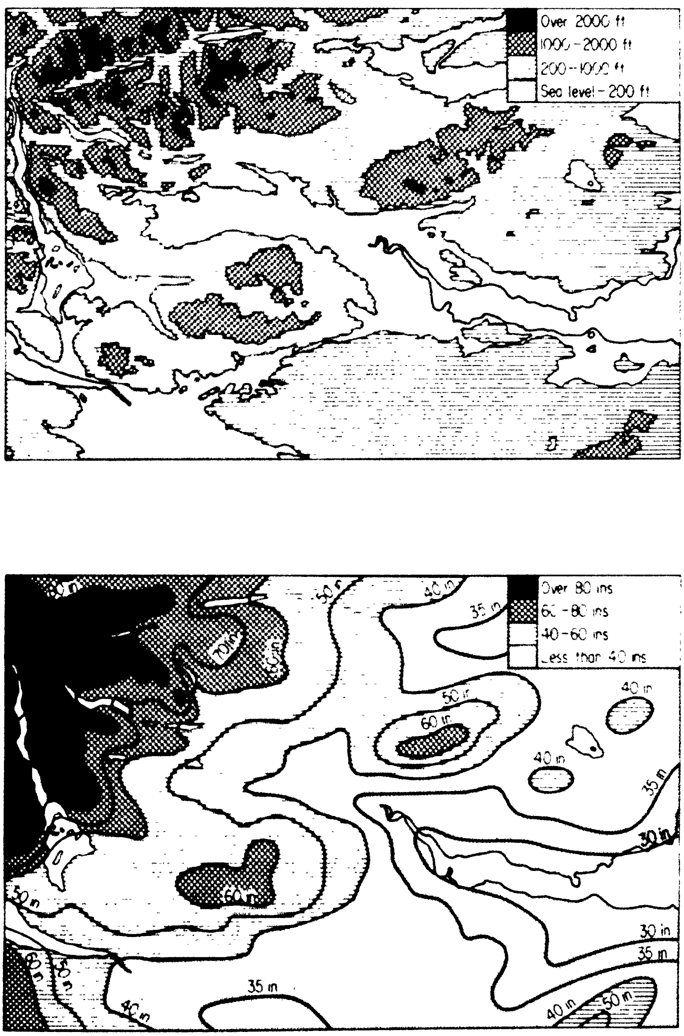



FIG. 62. The correlation between relief and rainfall in the Midland Valley of Scotland (after H. R. Mill)

## Sunshine and cloud

Some measure of this difference is afforded by the accompanying sunshine maps of the British Isles. Fig. 63 illustrates the advantages of situation along the south coast and along the east coast, and in lowland areas some distance

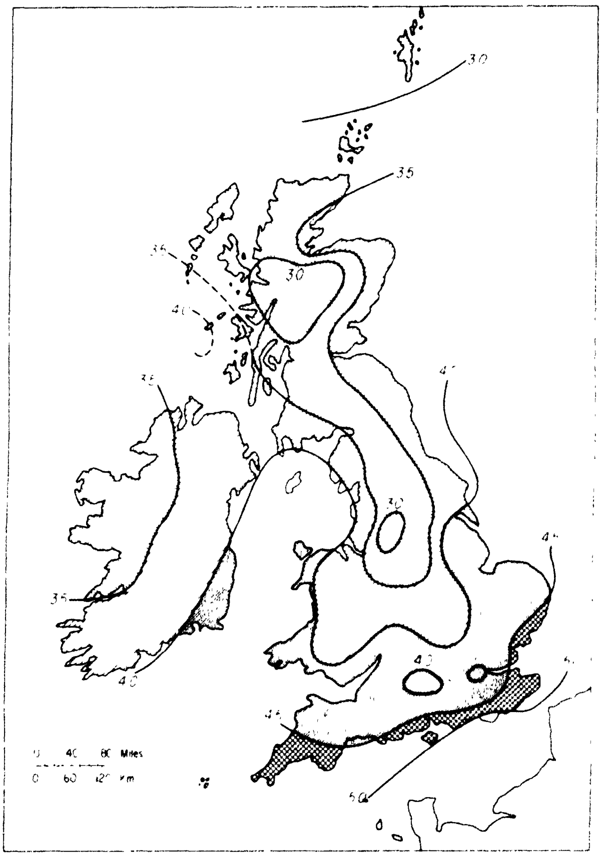


Fig. 63. Sunshine map of the British Isles, showing the average number of hours of sunshine per day throughout the year, 1906–35 (after E. G. Bilham)

from mountains which attract cloud. There is a general tendency, too, for a larger proportion of winter sunshine in the south, one reason being because of the longer winter days. It must not be forgotten that the northernmost part of Britain is sufficiently near the Arctic Circle for the summer nights to pass without complete darkness being reached, at least that is the case in the Shetland Islands in the latter part of June and July, when it is possible to read by the twilight. It is of some interest to note the way in which resort towns have seized upon salient facts of British climate for advertisement purposes. Common slogans include, 'South for Sunshine', while Skegness

on the 'drier side' of Britain is 'so bracing'. It may, however, be mentioned that the west coast scores in that slightly more rain falls at night than during the day, while along the east coast slightly more rain falls during the day than at night, the east coast districts experiencing thunderstorms during the late afternoon rather more frequently. The fame of the mild winters of the

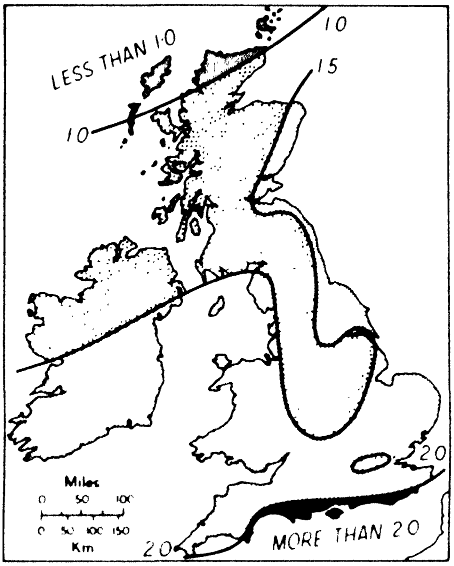



FIG. 64 January sunshine, expressed in number of hours per day

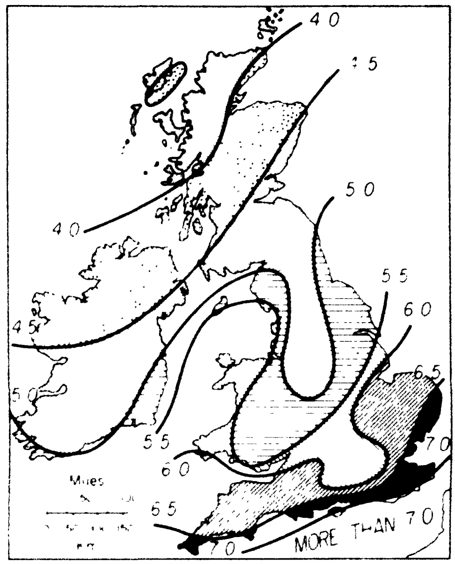



FIG. 65 August sunshine—the number of hours per day in the chief 'holiday month'

Mediterranean coast of France, or the French Riviera, was doubtless responsible for the application of the name 'Cornish Riviera' to the coast of Cornwall. Many years ago a poster on the Cornish Riviera express of the old Great Western Railway showed the Cornish peninsula on one side pointing to the southwest and the Italian peninsula on the other side pointing to the southeast, intending to suggest, of course, the similarity between the two. It is interesting to note that if one takes just the temperature records of coastal towns there is little difference between those of Cornwall and those of the French Riviera. For example, the mean January temperature of Penzance is 7°C (44°F), the January temperature of Nice is 8°C (46°F). The main difference comes in the sunshine records of 25 per cent of the possible for the months of December, January and February for Penzance and over 50 per cent for the same months for Nice. Even so the figures are sufficient to explain the reason why one should find such warmth-loving plants as the palm and the *Yucca* growing outdoors in the sheltered Cornish resorts and why they should justify their existence as winter resorts. Torquay, more accessible and developed with the amenities of a winter resort, has a January temperature of 6.8°C (42.3°F) and a sunshine record for that month of two hours per day.

## *Wind, fog and atmospheric pollution*

The dominant direction of the wind in the British Isles is from the south-west, though wind roses for differing situations show that the degree of dominance varies widely. Exposed situations on the western coastlines illustrate very well by the deformed growth of trees how important wind can be.

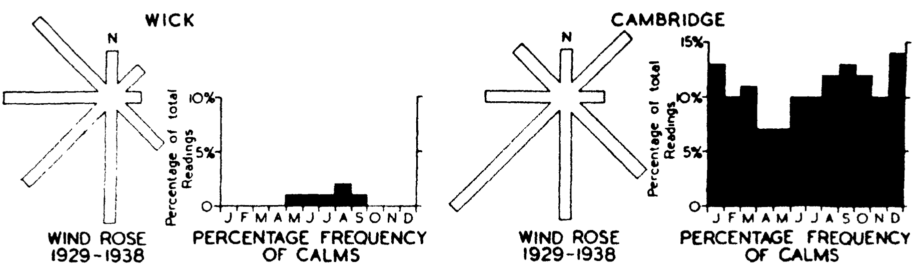



FIG. 66. Wind conditions in Wick, Caithness and Cambridge, 1929–38

At Stornoway in the Outer Hebrides the average number of 'days with gale' reaches 48 in every year; the Scilly Isles record 25. This may be contrasted with Tynemouth on the east coast with only four, and Kew, London, where normally none is recorded. A gale is defined officially as 'wind with a mean velocity exceeding 34 knots (63 kilometres per hour)'.

At least abroad, the British Isles have a reputation for fog, in very large measure undeserved. An attempt has been made, in the table adjoining, to show the number of foggy days in parts of the British Isles. Settled anti-cyclonic conditions in the winter are the most dangerous period. Sea mists, driving up the Channel, are most important, these being caused, of course, by the slight movements of damp, moist air reaching the colder air over Britain itself. Fog or sea mist of this sort is not infrequently responsible for delaying ocean vessels and was directly responsible for the discontinuance of a very useful way of crossing from Britain to the Continent from Tilbury to Dunkirk (Dunkerque).

Fogs in and around urban areas are frequently accentuated by atmospheric pollution. The old 'pea-soup' fogs of London, Manchester and other great cities were connected with the excessive use of imperfectly combusted coal and the humidity of the atmosphere. It was the disastrous London 'smog' of December 1952 that finally moved the Government to take action that ultimately resulted in the Clean Air Act of 1956. This disaster was caused by an excess of atmospheric pollution by soot and by sulphur dioxide derived from coal burning and the exhaust from internal combustion engines, under meteorological conditions that involved an absence of wind and a temperature inversion. Atmospheric pollution in some form, however, is always with us, particularly in and around large urban and

industrialised areas; its local effects vary enormously with wind direction and the nature of the air masses: polar maritime air with its high lapse rate and instability wafting the polluting elements aloft whilst stable air masses, often accompanied under anticyclonic conditions by temperature inversions, confine the pollution to lower atmospheric levels. Much has been done in recent years, through the introduction of smokeless zones in towns and the increasing efficiency of the combustion processes in, for example, thermal power stations, to reduce the incidence of pollution—but no attempt has yet been made to tackle the increasing menace in congested urban streets of motor vehicle exhaust fumes.

*Number of days per year on which fog is normally recorded (data from official pilot's manuals)*

| | | | | | |
|---|---|---|---|---|---|
| Falmouth | 10 | Yarmouth | 43 | Malin Head | 16 |
| Plymouth | 30 | Hull | 30 | Valentia | 5 |
| Portsmouth | 11 | Scarborough | 46 | Cork Harbour | 18 |
| Dungeness | 38 | Tynemouth | 39 | Donaghadee | 6 |
| Dover | 17 | Leith | 14 | Glasgow | 9 |
| Margate | 11 | Aberdeen | 18 | Liverpool | 18 |
| Shoeburyness | 42 | Wick | 21 | Pembroke | 45 |
| Greenwich | 46 | Stornoway | 5 | | |

London, Greenwich: Jan 7; Feb 4, Mar 3, Apr 1.5, May 0.5, June 0.8, July 0.1; Aug. 0.7, Sept 4, Oct 7; Nov. 10, Dec 7

Calculating the average duration of the fog at four hours on each day recorded, nowhere at the stations shown would fog occur during more than 2 per cent of the year, i.e. 98 per cent of the year is fog-free at the worst stations and 99.7 per cent at the best. Including sea mist, some stations, it should be noted, may be only 85 per cent mist-free

The term 'fog' is used by international agreement whenever the visibility is less than one kilometre (about 1,100 yards).

## Climate and health: urban climates

In recent years attempts have been made to measure more exactly the effects of different elements of climate on the health of human beings and on the prevalence of disease. Very little is really known of the direct effects of climate and what causes 'bracing' or 'enervating' and similar conditions. Prof. Melvyn Howe's work for the Royal Geographical Society and the British Medical Association on the *National Atlas of Disease Mortality* (1963) leaves no doubt as to the localisation of certain diseases but the factors are obscure. *Sudden* changes of weather act as dangerous irritants (e.g. in bronchitis) and, contrary to popular belief, cold dry snaps may be particularly serious. There are certain definitely 'urban' diseases, notably bronchitis, lung cancer, and pneumonia, and intensive studies are being made of urban climates. As T. J. Chandler has shown for London (*Geogrl. J.*, **128**, 1962, 279–302) most cities form in winter a definite 'heat-island' with a

much smaller temperature range than in the surrounding green belt or countryside. Both vertical and horizontal air currents are set up—some comparable to those shown in Fig. 58.

## Variations in British climate

There is a widespread belief that the climate of the British Isles is changing, and people are fond of saying that we do not get as severe winters now as occurred in the days of our forefathers; and they point out that it is now no longer possible to roast an ox on the ice of the Thames frozen over. In this particular example, as in so many others, the full facts of the case are not taken into consideration. If the Thames of the present day were allowed to flow almost unrestricted through banks very wide apart, it would doubtless freeze over just as easily now as it did of old. Some authors have been at great pains to collect accurate information, and it would seem that the weather of the British Isles does tend to occur in cycles, and a correlation may perhaps be possible between these cycles of weather and the occurrence of sun-spots. Gordon Manley in his *Climate and the British Scene* reviews the evidence and the present state of knowledge at some length; it would seem that there may be both major and minor cycles of weather. At the same time it is, of course, important to remember that in the early days of man's habitation of Britain, the country was under the influence of the great Ice Age, and there has, *on the whole*, been a steady change from that time to the present, with an increase in temperature and a decrease in humidity, though there is evidence for relatively wet or 'pluvial' periods in Neolithic and Roman times inter-

| | | CLIMATE | | VEGETATION |
|---|---|---|---|---|
| Post Glacial | 800 B.C.–present | Sub-Atlantic | Cool and wet | Zone VIII Alder birch oak (beech) |
| | 3000–800 B.C. | Sub-boreal | Drier | VIIb Alder mixed oak elm lime |
| | 5000–3000 B.C. | Atlantic | Warm and wet | VIIa Alder mixed oak elm lime |
| | 6800–5000 B.C. | Boreal | Warm and dry | VI Hazel pine; V Hazel birch pine |
| | 8000–6800 B.C. | Preboreal | Rapid amelioration | IV Birch |
| Late Glacial | 8800–8000 B.C. | Upper Dryas | Cold | III Park tundra (birch copses) |
| | 10,000–8800 B.C. | Allerød | Milder | II Birch woods |
| | 12,000–10,000 B.C. | Lower Dryas | Cold | I Park tundra (local birch) |

The Upper paleolithic corresponds with the Late Glacial, the Mesolithic lasted till about 2500 B.C., the Neolithic and Bronze Ages to 800 B.C., followed by the Iron Age and Romano-British.

rupting the general change in an interglacial period, and evidence is lacking as to whether the climate as a whole is still getting milder or not. Climatic fluctuations since the disappearance of ice from Britain have played a major part in the development of the present flora and fauna.

The table on p. 86 is based on the tentative one in H. Godwin's *The History of the British Flora* (1956), p. 62, and takes account of radio carbon dating.

It is probable that these climatic fluctuations are intimately connected with the final separation of Britain from the continent, and the establishment of the present oceanic circulation. The climatic periods in Britain are not necessarily contemporary with those established on the continent.

# 5
# The inland waters of the British Isles[1]

Of the rain that falls on the surface of the British Isles, part evaporates, part soaks into the ground, and part, usually a large part, runs off to form streams and rivulets, and eventually finds its way into the rivers of the country. That which percolates into the soil and into the rocks of the earth's crust is in part utilised by plants growing therein, and may eventually pass back into the atmosphere; but some of this water joins the underground water table and becomes part of an underground supply, being gradually returned to the open where the water table comes to the surface, and the water thereupon reissues in the form of springs. Although work discussed in the last chapter has shown considerable variation in evaporation from one part of the country to another, over a large part of lowland Britain from exposed surfaces of water (e.g. lakes and reservoirs) it is equivalent to about 400–600 millimetres (16–24 in) of rainfall (Fig. 61). Thus in areas with a rainfall of 600–1500 millimetres (25–60 in) from 30 to 60 per cent (over large areas between 40 to 50 per cent) of the rainfall is lost by evaporation. This takes into consideration the greatly varying evaporation from land surfaces. It is not the purpose of this chapter to study the behaviour of underground water, or even of surface streams; but to regard the sum total of rain falling upon the surface of the British Isles as one of the natural resources of this country, and to study its utilisation.

## The evolution of British rivers

The evolution of the existing British river system falls into three phases:

(*a*) The preglacial phase;
(*b*) the period of glacial interference;
(*c*) the period of man's interference.

It is certain that the main lines of the present relief of the British Isles were outlined before the coming of the great Ice Age. On the whole, many of the rivers must have followed substantially their present courses. In England and Wales, it is probable that the Highland Zone on the north and west of the country exercised a greater influence than it does at the present day, and that there were many rivers draining from the higher lands of Wales, or the

1. We are indebted to Professor W. G. V. Balchin for valued help in the revision of this chapter.

north of England, following the general slope of the land towards the southeast (see Fig. 13). The tectonic depression of the Thames Basin considerably antedates the glacial period, and it is likely that these southeasterly flowing rivers made their way into what may be called the proto-Thames.[1] The extreme southeast of England—the Wealden area—is the classic area in the study of river development, mentioned above. The coming of the great Ice Age and the formation of huge ice sheets over the north of the country

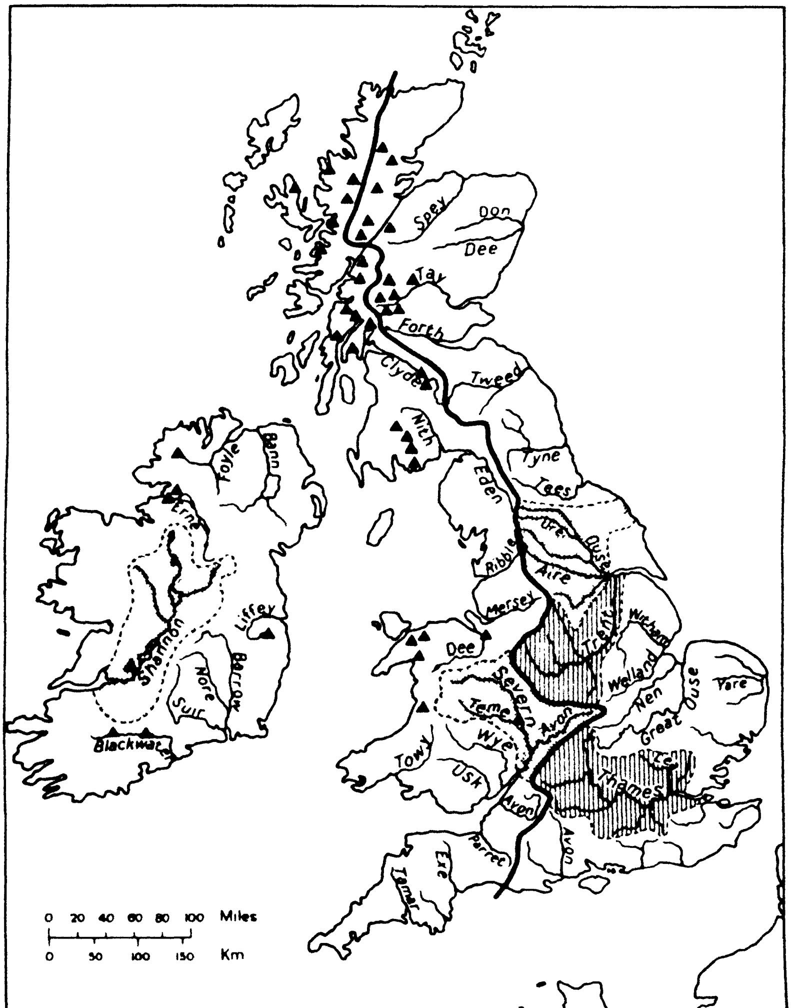



FIG. 67. The chief rivers of the British Isles

The heavy line shows the main water parting, five of the larger basins are separately indicated. The black triangles are some chief points where water power has been developed

1. For correction of this oversimplified statement see S. W. Wooldridge and D. L. Linton, *Structure, Surface and Drainage in South-east England*, Publication no. 10, *Inst. Br. Geogr.*, 1939, reissued, 1955.

must have obliterated there the free surface drainage. As the ice spread southwards so natural drainage channels were in many cases blocked and pent-up waters were compelled to find their way into new channels; in many cases they have never gone back to the old ones. The tongues from the ice sheets were responsible for the deepening of many of our valleys, especially in the Highland Zone. Thus many of the lochs of Scotland are of glacial origin, so also are the lakes of the Lake District; whilst amongst the higher parts of the mountains of Wales the circular 'cwm' or corrie lakes do much to add to the beauty of the scenery of that country. With the gradual departure of the ice sheet many pre-existing valleys were thickly covered, perhaps even obliterated, with glacial debris, effectively blocking old lines of drainage. In the lower parts of the country, especially where the glacial debris was clayey or impervious in character, there resulted the ill-defined drainage which to this day is characteristic, for example, of so much of the Central Plain of Ireland. Amongst the other marshy lands left behind were the Vale of York and the Fenlands of England.[1] The third stage in the evolution of the river system of the British Isles has been marked by the small, but cumulatively important, efforts of man to control drainage and more especially to drain some of the lower lying areas. How successful this has been can be judged by the complete conversion of the Fenland into what it is today—one of the best agricultural regions in the British Isles and the almost equally complete drainage of the Vale of York. To a less extent man has controlled the drainage of the country for his own ends, for purposes of water supply.

## The utilisation of the water resources of the British Isles

It is remarkable, indeed well-nigh incredible, that there has been until comparatively recently no comprehensive study of the freshwater resources of Britain. Whilst almost from time immemorial such rivers as the Nile have been studied day in and day out, and their exact flow measured by gauges, few such records exist for British rivers. The seasonal rise and fall of rivers is a study of the utmost importance in many countries of the world. Their characteristic regime, as this rise and fall is called, may be a factor of national significance. The Thames, because of its importance for the water supply of London, was the only river whose resources were comparatively accurately known. What was the reason for this neglect of the study of an important national resource? It is in the main a reflection of the climatic conditions of these islands. Broadly speaking, in the past we have always had a superabundance of water for our requirements. The trouble has

1. For an account of some outstanding examples of glacial interference with drainage, see L. J. Wills, *The Physiographic Evolution of Britain*, pp. 211 28. Many of the papers listed under References for this chapter deal with the evolution of drainage (see p. 815).

usually been too much water, and the difficulty of getting rid of the surplus. Thus the necessity of organising a survey of our national water resources has not, until comparatively recent times, become apparent.

The Meteorological Office, as mentioned in the last chapter, is responsible for the collection of statistics of rainfall. The Geological Survey has concerned itself with underground water and since 1899 has published a series of water-supply memoirs on the counties. In these details of underground supplies from water-bearing deposits or aquifers and existing wells are given. The importance of water in the war effort of the Second World War led to a systematic recording of information in which the Water Unit of the Geological Survey played an active part, and notification of the results of well boring is now compulsory. What remained neglected was the surface water—the behaviour of rivers and the supply which is available from them for all purposes. In 1932 the British Association for the Advancement of Science appointed an Inland Water Survey Committee to study the means whereby such a survey could be undertaken. An Inland Water Survey Committee was set up by the Government in 1935 and a *Surface Water Year Book* published for 1935–36 and 1936–37. Both the Committee and the Year Book faded out during the War, to be resuscitated later. The Committee sponsored the publication of the *Surface Water Year Book of Great Britain*, 1937–1945 before the Committee was again suspended as an economy measure. It is clear that engineers of all important water supply and power undertakings must have an accurate knowledge of their resources and so carry out river gauging and flow measurements. The information available is collected in the *Year Book*. Some river basins (such as the Ness in Scotland, the Nene and Wye in England and Wales) are reasonably well covered: for much of the country there is still little information despite the anticipation by the Government in 1944 of a national water policy.[1]

As the standard of living rises and all houses have running water and baths, 205 litres (45 gallons) or more per day must be allotted to every individual. Indeed, this figure is constantly being increased. In some parts of the United States it has exceeded 680 litres (150 gallons). Some modern industries, e.g. paper making and rayon manufacture, make enormous demands on water. The great urban centres seek their supplies in distant mountainous areas and the water is brought by aqueducts across rural land which may be very short of water. A modern dairy farm requires at least 136 litres (30 gallons) per cow per day, but few reach this standard unless they can have mains supply. In the country as a whole, domestic consumption is now running at the rate of some 2.7 million million litres (600 000 gallons) a year, and industrial consumption at about 1.36 million million litres (300 000 million gallons) a year.

In the utilisation of our water resources it may be said that there are at

1. *A National Water Policy*, Cmd 6515, HMSO, 1944.

least five frequently conflicting interests which regard the water resources of the islands from five different points of view:

land drainage,
water supply for domestic, agricultural and industrial purposes,
transport (i.e. navigation),
water power,
fisheries and recreation.

## Land drainage

In 1927 a Royal Commission, under the chairmanship of Lord Bledisloe, was appointed to inquire into the whole question of land drainage in England and Wales. In the evidence presented to that Royal Commission it was stated that there were 710 750 hectares (1¾ million acres) of land in England and Wales alone in urgent need of drainage, and that 1 766 610 hectares (4 362 000 acres), about one-seventh of the land in agricultural use, depended absolutely on artificial drainage.

Land drainage is a complex matter. With the heavy rainfall over much of Highland Britain there is commonly an excess of water for agricultural purposes. Unless this is drained away soils become more and more acid and incapable of yielding good crops, grassland becomes waterlogged and the place of nutritious grasses is taken by reeds, rushes and mosses such as *Sphagnum* till the land becomes a useless bog. Two types of drainage are needed, one to drain off surface water, hence open ditches, the other to drain the soil, hence pipes a foot or so below the surface or channels cut underground by an implement which works like a mole (mole-drainage). It has been estimated that in 1939, 3.6 million hectares (9 million acres) or 40 per cent of the farmland, excluding rough grazings, or a quarter of the total surface of England and Wales was in need of drainage of these types. Much work was carried out during the Second World War especially by prisoner of war labour but in 1952 the Drainage Division of the Ministry of Agriculture estimated that 1.4 million hectares (3.5 million acres) were still in urgent need of drainage.[1] It will be seen that these greatly exceed the figures previously given to the Royal Commission.

The more effective the drainage of agricultural land, the greater the run off and the greater the danger of flooding from rivers overflowing their banks. There are still many parts of the British Isles which are subject to disastrous floods. To quote one example, in the valley of the lower Don, no less than 79 per cent of the total area of 86 062 hectares (212 500 acres) of the Doncaster area is below the 8 metre (25 ft) contour, and in urgent need of provision of adequate drainage.

The position is that the natural river channels are only sufficient to take off the surface water in times of normal flow and prove quite inadequate in

1. See also *Land Drainage in England and Wales*, Cmd 916, HMSO, 1959.

times of excessive rainfall, which therefore results in widespread flooding. In the past, land drainage engineers have had to take a purely arbitrary figure in calculating the run-off from the catchment basin with which their works would have to deal. It has been considered as reasonable to take as a normal maximum run-off one-hundredth part of the average annual rainfall over the catchment area for twenty-four hours. Thus, if the average rainfall of the catchment area is 635 millimetres (25 in) per year, it has been considered necessary to construct the drainage works to take off the equivalent of 6 millimetres (0.25 in) per twenty-four hours. This is admittedly insufficient to deal with exceptional floods, but the cost of providing for a flood which might occur once in fifty years is entirely prohibitive. Taking the case of the River Thames, for which some accurate figures do exist, the largest flood recorded was due to very exceptional rainfall in the year 1894 when the discharge at Teddington Weir reached 92 million litres (20 236 million gallons) per day or 37 600 cusecs on 18 November. This is equivalent to 15.25 cusecs[1] per thousand acres over the whole catchment area, or equivalent to 9 millimetres (0.36 in) of rain on the whole area of the Thames Basin. In the 26 days from 23 October to 17 November 1814 over 203 millimetres (8 in) of rain fell in the Thames Valley, or an average of 7 millimetres (0.31 in) per day. The Thames when it is running bank high was able to discharge 20 457 million litres (4 500 million gallons) per day—a quantity which has been exceeded on about twelve days per year since 1883. Improvement works later undertaken between Weybridge and Teddington enabled the river to discharge roughly double this quantity. It is not considered practical to provide for floods of greater magnitude which are of very rare occurrence. Thus it must be accepted that some 60 750 hectares (150 000 acres) in the catchment area of the River Thames are subject to inundation in times of high floods and that they must remain so subject. By way of contrast, the minimum flow recorded for the Thames at Teddington is 75.9 million litres (16.7 million gallons) per day or 31.0 cusecs on 29 October 1934.

Broadly speaking, it is only in the smaller catchment basins that a single day's heavy rainfall will be reflected in a serious flood. Thus in east Norfolk, one of the most disastrous floods on record of the river Wensum (on 6 August 1912) was due to a fall of rain of 505 millimetres (7.3 in) in one day, though the river provided itself automatically with water storage by overflowing the lowland on each side to the extent of 4047 hectares (10 000 acres). Similarly the disastrous flood in August 1952, which destroyed much of the Devon village of Lynmouth with a serious loss of life, was due to a cloudburst higher up the tiny valley: 228 millimetres (9 in) of rain fell in one day, most of it in three hours.[2] In 1959, as a result of a dry summer, a

1. Cubic feet per second. One cusec = 538 000 gallons a day and 1 000 000 gallons a day = 1.86 cusecs.
2. C. Kidson and J. Gifford, 'The Exmoor Storm of 15th August 1952', *Geography*, **38**, 1953, 1–17.

quarter of the people in England and Wales were restricted in their use of water, whereas in 1960 and 1968 the wet summer led to serious flooding in many areas.

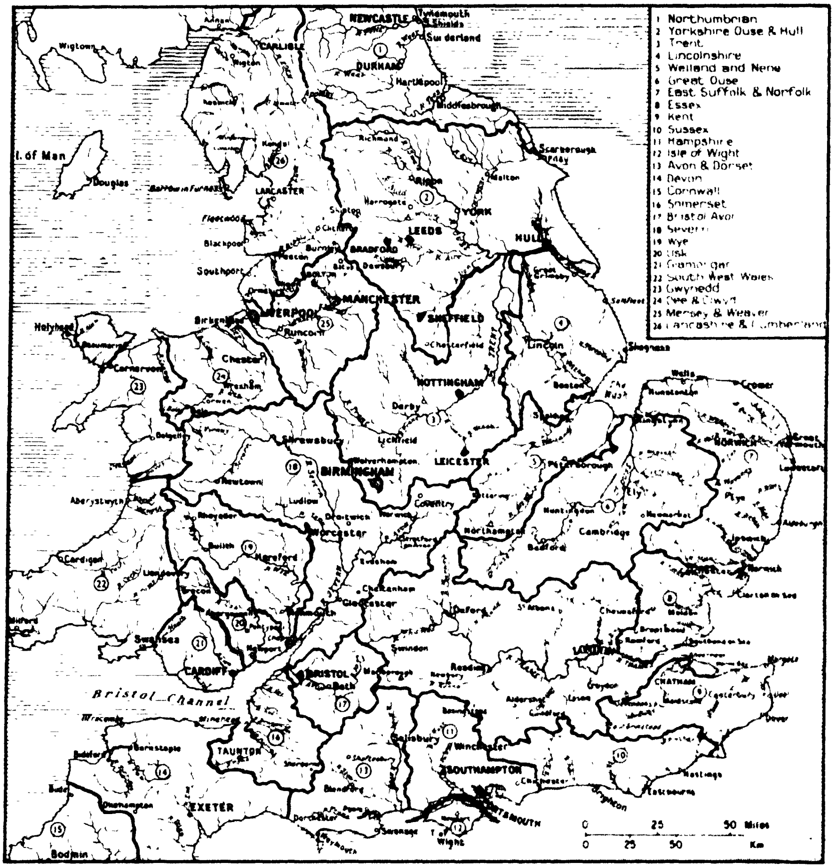



FIG. 68. Water areas under the Water Resources Act 1963

Summarising, much land in the British Isles still requires drainage to render it of greater agricultural value, though much has been done in recent years. The channels of main rivers in particular require improvement so that they are able to take off up to about twice the water which they can take off at present. Payment for such work may be obtained by rates on the owners of land situated below the flood level, taken normally as 2.4 metres (8 ft) above the mean level of the river, but it is often contended that upland owners should pay for the privilege of discharging their surplus water with danger to lowland owners and that rates should be levied over the whole of a basin.

The Land Drainage Act 1930 provided for the division of England and Wales into forty-seven catchment areas for which Catchment Boards were

constituted. This was an important step, but it was the Water Act 1945 which laid the foundations of a national water policy. At the time of the 1930 Act there were over a thousand statutory water authorities—borough, urban and rural councils—and about a thousand water supply companies in England and Wales alone. The decisive legislation was however the Water Resources Act 1963, setting up a new central authority, the Water Resources Board, charged with the duty of conserving, distributing or otherwise augmenting water resources, including supplies from watercourses, lakes, and underground water. The Act set up twenty-six River Authorities for England and Wales and to them were transferred the powers and duties of the former River Boards. The Ministry of Agriculture remains responsible for land drainage and fisheries. A 'river basin' in English usage is called 'watershed' in America and the function of the new British River Authorities is what would be called watershed management in America.

## Water supply[1]

The object of the land drainage engineer is to drain the land effectively and conduct the water as easily and as quickly as possible to the sea; the object of the water supply engineer is to conserve a supply of pure, good quality water so that it may be available in quantity to the populace at large at all seasons of the year, independent of periods of drought. The supply is derived from three main sources:

(*a*) Shallow wells which go down as far as the permanent water table, and from which the water can be pumped up.
(*b*) Deep wells tapping deep-seated, including artesian, water.
(*c*) River supplies, or gathering grounds whose water has been conserved in natural lakes or artificial reservoirs.

In country districts the normal water supply is still obtained to a certain extent from wells, supplemented in many cases by supplies from natural springs. In 1914 out of 12 869 parishes in rural districts in England and Wales, only 4874 had a piped water supply even to some of the houses. In 1939, according to the Scott Report, 3432 parishes and at least a million of the rural population were still without piped water. In the same areas the method of disposal of sewage is by cesspools or pits in the ground, and the relative siting of well and cesspool is a matter of the first importance. There is in the underground water table a definite movement of water, usually, but by no means always, down hill by relationship to the surface of the ground, and obviously the cesspool should be on the downflow side from the well. Even with the utmost precaution pollution is likely to occur and with an increase in population the provision of a piped water supply is a

1. For matters relating to water supply the standard work is R. C. S. Walters, *The Nation's Water Supply*, 1936, which is a mine of information. For later statistics see successive editions of *British Waterworks Year Book and Directory* and the official publications already quoted.

first essential. The drilling of deep wells is perhaps most frequently undertaken by firms and individuals who wish to have an assured supply apart from that provided by water supply companies.[1] Where there are numerous wells drawing upon a deep-seated underground supply, particularly an artesian supply, as under London, it has become quite clear that the water is by no means inexhaustible, and the level of the artesian water under London has been lowered appreciably within the last fifty years.

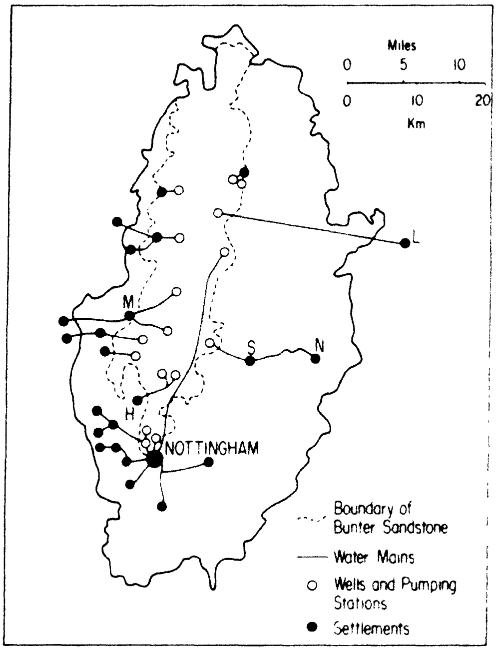



FIG. 69. Sketch map illustrating the importance of certain geological horizons (in this case the Bunter Sandstone) as water-bearing beds (after Professor H. H. Swinnerton). The most valuable water-bearing formation in south-eastern England is the chalk, but many permeable or partly permeable beds such as sandstones and fissured limestones are locally important. Surface gravels are liable to pollution

The problem of water supply is obviously most acute in the large conurbations. In many cases, as for example, London, provided the quantity of water removed does not affect the use for transport, navigation, and other

1. In England and Wales every landowner has the right to use, but not to sell, water naturally flowing through, past, or under his land provided there is no interference with the rights of neighbouring landowners. There is now however a certain restriction on new borings. Private rights to impound rivers and draw water are drastically restricted by the Water Resources Act 1963.

interest of the riverine owners, it is possible to draw a water supply from all the larger rivers. In some cases the water is drawn directly from the river and simply passed through filtration plant before being distributed but in other cases it is drawn off first into storage reservoirs. Amongst the rivers whose water is used may be noted the Yorkshire Ouse and the Trent, the Wye, Severn and Bristol Avon, the East Anglian rivers and those draining to the Wash, the Tees and Derwent and many smaller rivers. The outstanding example, however, of the use of river water is that of the Thames for London. The bulk of London's water supply is taken from the Thames above Teddington, supplemented by a considerable supply from the River Lea or the New River Waterworks, and from wells. The springs and wells used to supply London from early times proved inadequate as early as the sixteenth century and the 'New River Scheme' to bring water from Chadwell and from Amwell near Ware in Hertfordshire was sanctioned by Parliament in 1606 and completed in 1613. The Thames water, more than two-thirds of the whole London supply, is taken off and stored in great reservoirs.[1] Fears of a shortage have led to various proposals for distant supplies, notably from south-central Wales.

In some of the other conurbations the problem is not quite so simple. Obviously the most suitable collecting grounds for water supply for a large city are the open moorlands or hilly areas which have a heavy rainfall, but where there is not a large animal or human population living on the hills which would naturally pollute the supply of water. Thus it is not too much to say that there has been a scramble amongst the more powerful city corporations to secure rights for this purpose over the more thinly inhabited parts of Wales, the Pennines, the Lake District and elsewhere. There is great competition amongst the towns on the two flanks of the Pennines to secure the rights for areas of drainage and water supply from the Pennines themselves.

Water from the Pennines supplies the needs of over 20 million people, and reservoirs, as shown in Fig. 70, are closely spaced. But the supplies were obviously becoming inadequate. The Corporation of Liverpool cut the Gordian knot by damming the Vyrnwy valley in Wales, thereby creating Lake Vyrnwy, with a surface about 250 metres (825 ft) above sea-level. It formed the largest single inland sheet of water in Wales and at that time the largest artificial reservoir in Europe—8 kilometres (five miles) long and on an average nearly 1.5 kilometres (a mile) wide. It was constructed between the years 1881 and 1892, and has a surface area of 454 hectares (1121 acres), its storage capacity being 55 147 million litres (12 131 million gallons), and the catchment area nearly 94 square kilometres (36 square miles). The aqueduct is 105 kilometres (65 miles) long. The Vyrnwy, it should be

1. It is thus true to say that the bulk of London's water supply is in fact purified sewage—for the Thames has received the effluent from all the towns on its banks upstream of the Metropolis.

added, is the chief Welsh tributary of the river Severn, and was formerly a small stream meandering across a marshy flat. The suitability of the site depended to a considerable extent on the hard old rocks of the neighbourhood forming a suitable foundation for the masonry of the reservoir dam.

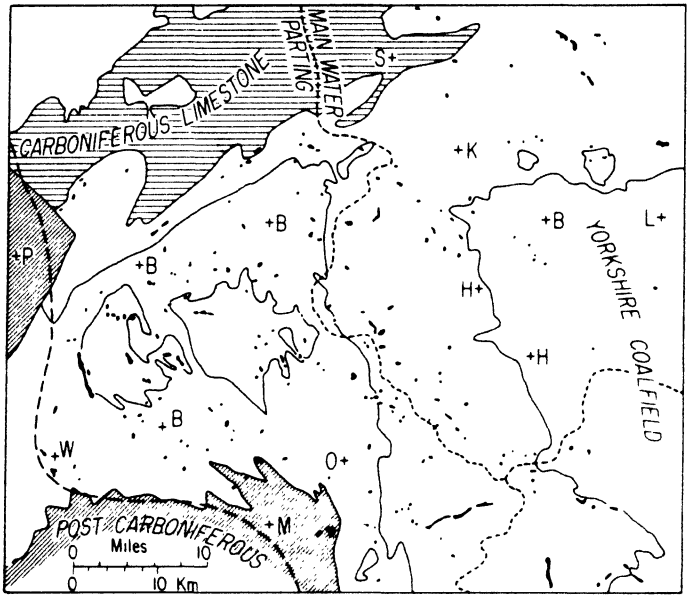



FIG. 70. The Pennines as 'gathering grounds' for water supply

All the black areas are reservoirs and no less than 220 are shown on this map. The blank areas are Millstone Grit and Coal Measures, on which nearly all the reservoirs are situated. The broken line in the west is the western limit of 'soft' water (see Chapter 20)

The Corporation of Birmingham followed suit by constructing a series of four reservoirs in the beautiful valley of the Elan about four miles west of Rhayader. These were completed in the years 1893–1904 at a cost of no less than £5,750,000. They cover 364 hectares (900 acres) and yield a daily supply of 341 million litres (75 million gallons) from a gathering ground of about 181 square kilometres (70 square miles), the storage capacity exceeding 45 461 million litres (10 000 million gallons). Provision was made for later extensions of the supplies. From the reservoirs there are, of course, gigantic aqueducts, for the most part near the surface, though hidden, running for more than 117 kilometres (73 miles). Parts of the aqueduct, totalling 59.5 kilometres (37 miles), are actually siphons where the water is under pressure from the heart of Wales to Birmingham. In 1952 a further supply was obtained from the new Claerwen reservoir. Manchester has utilised the natural lake Thirlmere in the Lake District under the shadow of Helvellyn. A fear that the supply from Thirlmere would be insufficient for the growing city led to the development of another scheme in the Lake District for using Haweswater. Manchester had secured the rights to Hawes-

water against much opposition from those interested in local supplies and there were indignant protests when the scheme was postponed in 1932 as not immediately necessary. In due course, however, Manchester not only developed Haweswater but again fearing a shortage negotiated in 1962 for the right to use Ullswater. Countrywide opposition, mainly on amenity grounds, caused the project to be shelved, at least for the time. The necessity for sharing available supplies had been accepted as early as 1899 when an Act of Parliament apportioned the waters of the Derwent valley between the cities of Leicester, Sheffield, Derby, and Nottingham and the counties of Derby and Nottingham. Great works have been constructed on this basis of which the most noteworthy is the Ladybower Reservoir.

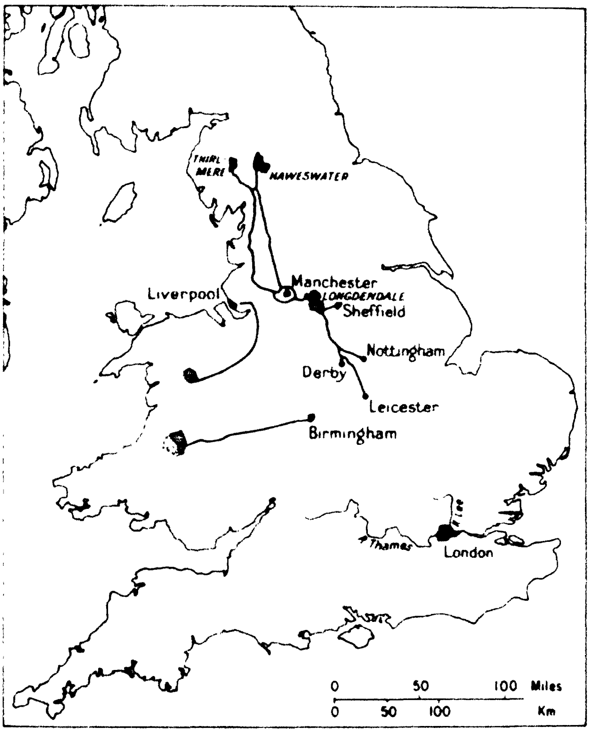



FIG. 71. Map of England and Wales showing some of the long-distance urban water supplies

During the Second World War, the needs of agriculture for water became apparent and were stressed in the Scott Report, but the Water Resources Act was not passed until 1963.

For certain industrial purposes, the quality or type of water is of importance. Thus it is well known that the supplies of soft water were in part responsible for the location of the textile industries of Lancashire and Yorkshire, since soft water is so essential for washing and dyeing the raw materials and fabrics (see Chapters 19 and 20). But with the modern development of

water softeners, it is relatively easy, though expensive, for firms concerned to install the necessary apparatus, just as the railways did, in the days of steam locomotion, for softening their water. Similarly, although the local well water from the gypseous Keuper Marls with its considerable permanent hardness was largely responsible for the development of the brewing industry at Burton, 'burtonisation' or artificial hardening of water for brewing is now commonplace. For other purposes, too, soft water may be a disadvantage. If passed through lead pipes it is apt to dissolve so much lead as to become poisonous.

Although for domestic supplies, emphasis is on the 'purity' of water it is now recognised that for maintenance of health certain salts should be present. In particular fluorine is needed for the development of children's teeth and many water authorities now undertake a fluoridation of drinking supplies.

### Transport

The utilisation of British inland waterways for transport and navigation purposes and their linking by canals is considered elsewhere (see Chapter 26). It may be noted here, however, that the land drainage engineer in embanking the rivers to prevent excessive flooding also benefits the users of waterways in that the firmness of banks is secured, and a deeper and narrower channel tends to be formed. Many of our rivers have been changed out of all recognition in this way. Thus it is difficult to imagine at the present time a ford across the Thames, as undoubtedly there was in early times, in the neighbourhood of London Bridge. The river has been so enclosed by embankments on either side that the current has become swift, and the actual watercourse deep. It may be appropriate to mention at this point, too, the enormous importance of the mouths of British rivers. The river mouths are often more important than the rest of the river because of the situation thereon of many of our great ports. Here the climate of these islands, with its well-distributed rainfall, is responsible for the steady flow of most of our rivers throughout the year. This, combined with the marked tidal scour consequent on the large tidal range characteristic of the continental shelf round the British Isles, has been in a large measure responsible for the development of so many of our ports.

### Water power

The water power resources of the British Isles are not large. In the days before the extensive use of coal, small swift streams such as those running down from the Pennines were extensively used for driving machinery. The sites of the early forges and grinding works—for example in the Sheffield district—were determined by the water power available from the streams.

In the Sheffield area it is still possible to see the 'hammer ponds' in which water was impounded and so used for turning water wheels which operated mechanical hammers for working the iron. Similarly the water was used for working the bellows in the forges. Some of the cotton mills in South Lancashire were likewise located, as were woollen mills in Yorkshire, where water power was available from the streams. In many parts of the country water power was used in small flour mills, but most of these primitive establishments have fallen into disuse. A water wheel where such exists for grinding grain or for sawing wood has now become a tourist attraction, and more money is likely to be earned by the proprietor in providing teas for visitors than in any benefit he derives directly from his mill.

About fifty years ago the Board of Trade appointed a Water Power Resources Committee to enquire into the hydroelectric power resources of the British Isles. They calculated that if all the schemes up before them were developed 250 000 kW could be generated out of which 210 000 were regarded as developable on an economic basis. This was the total for Great Britain, made up of 195 000 kW in Scotland, 36 000 in Wales, and 26 500 in England. It was estimated that the output would reach 1840 million units or kilowatt-hours per annum, and would represent a saving of some 3 million tons of coal a year. This theoretical possibility was actually equal to 40 per cent of the total units generated in 1917–18. Since then the enormous increase in the demand for electricity has altered the picture completely, and the modern development of hydroelectric power is considered in Chapter 14.

## Fisheries and recreation

Most of the British rivers were once celebrated for their trout, their salmon, and for other fish. Many have become so polluted that the fish have disappeared, but in others fishing is carefully preserved and the sporting rights guarded by angling societies and private owners. Fishing rights on the best trout streams in the south of England let at £5000 per mile of stream. It is difficult to calculate the value of freshwater fish in British rivers. Possibly the value of salmon and other fish obtained in Ireland approaches £1 million annually; the annual value of salmon from Scottish rivers is officially estimated at the same figure. In recent years increased attention has been paid to the restoration of inland fisheries by preventing further pollution. In the new hydroelectric power schemes it is now standard practice to provide fish ladders. In some, such as that near Pitlochry, the salmon are automatically counted as they ascend.

Apart from sport fishing the inland waters of Britain have assumed in recent years a new or renewed significance in the recreational life of the country. Nearly every lake has, if the controlling authorities permit, its quota of pleasure boats—canoes, rowing boats, outboard motors, yachts, and motor boats of all types. The advent of the speed boat, disturbing by its

noise and wave-creating habits fishermen, nature-lovers, and the users of other craft, has created difficulties and dissension. Many stretches of inland water now have their 'marinas'; both rivers and canals are valued more for boating than for any other purpose and active steps have been taken in many areas for the preservation of canals as rural amenities.

# 6
# The soils of Britain

Pedology, or the study of soils, is a study which as a modern science is still young, but much progress has been made since this book was first published. The soil is, broadly speaking, the surface layer of the earth in which plants grow. The mineral matter is in the main derived from the underlying rocks which have weathered and it might be thought therefore that this part of the soil would vary directly according to the character of the underlying rocks, and that therefore a geological map would form the necessary basis for the construction of a soil map. More and more of recent years however it has been recognised that climate plays a leading, even a dominant, part in determining the character of the surface soil. So much is this the case that it is possible to distinguish, as American writers have done, two great soil groups in middle latitudes. The *pedalfers* are those commonly formed where rainfall is in excess of evaporation, and where there is normally therefore a tendency for the more soluble mineral salts, including lime, to be dissolved out of the surface layers and washed downwards, leaving a soil rich in the elements aluminium (al) and iron (fe), hence the name pedalfers. Where on the other hand evaporation exceeds rainfall there is an upward movement of moisture in the soil, and when the moisture is evaporated the previously dissolved salts are left behind in the surface layers, which thus become rich in such salts as calcium carbonate, hence the name *pedocal*. Where there is an approximate balance between rainfall and evaporation conditions are often particularly suitable for the accumulation of organic matter, and the development of a *chernozem*, or black earth. These great soil groups are termed 'zonal' in the sense that we may speak of major world climatic zones.

It has already been noted in the preceding chapter on climate that in all parts of the British Isles rainfall normally exceeds evaporation, and hence the soils of the British Isles are normally pedalfers. Further, the whole of the British Isles lie in one climatic region, and that is not one of extreme conditions. Hence the soils of the British Isles do not show the great differentiation due to climate which is characteristic of such large tracts as the plains of European Russia, or of the heart of North America. Most of the soils of the British Isles belong to two of the great world soil groups, the podzols and the brown forest soils, together with a limited development locally of special types. Actually in the British Isles the soils vary enormously but according

to parent material or human influence, and Britain has thus, despite the uniformity of climate, a remarkable range of soils which are sometimes for obvious reasons described as 'aclimatic' or 'intrazonal'.

The pioneer studies of soil in Britain were mainly the work of agriculturalists concerned in the use of soil. In 1793 a state-aided independent organisation known as the Board of Agriculture and Internal Improvement was set up, and it prepared a series of county studies each of which bore the general title *General View of the Agriculture of the County of X with Observations on the Means of Improvement*. These were published first in a preliminary form, inviting comments, and later in a permanent form from 1794 onwards. In each the first chapter has a section devoted to soils, and most of the volumes include a soil map, sometimes a hand-coloured folding plate. In many of the counties of Britain this remains, more than 150 years later, the only soil map of the county. The descriptions of the soils were based primarily on texture, e.g. loams, clayey loams, black peat earths, and so on, with special types in certain counties such as the brashy soils on the Oolites, or descriptions which would be appreciated by farmers, such as 'a turnip soil'. These primitive soil maps are of such interest that they have been reproduced in black and white, sometimes simplified, in the County Reports of the Land Utilisation Survey of Britain, published under the title of *The Land of Britain*.

When the Geological Survey was set up in 1835 it was laid down as one of the objectives that maps of surface deposits and soils should be prepared to serve the needs of agriculture. For the most part this objective remained in abeyance, and although the Survey has now mapped the solid geology over the whole country, there is still no complete drift map.[1] In a few areas the Geological Survey found time from its work of mapping geology to produce a soil map, the basis of which was the texture of the soil. Two coloured maps, covering a large part of Ayrshire, were published, and a soil survey was carried out of a considerable part of the Eden Valley in Cumberland. The maps distinguish such groups as light sand, coarse sand, light, medium, and heavy loams, and so on, but a different scheme is adopted for each sheet. These maps are interesting because they represent a breakaway from a geological basis of classification and a return to the basis of texture.

An important landmark was the publication in 1911 of *The Agriculture and Soils of Kent, Surrey, and Sussex*, by A. Daniel Hall and E. J. Russell (afterwards Sir Daniel Hall and Sir John Russell). They were concerned with the soil as a medium for farming and their mechanical analyses were based on a well mixed sample of the surface layers, a procedure entirely different from the modern methods which study the separate layers in the soil, or the soil profile. The foundations for the modern concepts of pedology, or soil science, were laid particularly by the Russians under the leadership of V. V. Dokuchaiev, and by the Americans under the leadership of C. F. Marbut.

1. A small scale map was prepared in 1958–59 by Prof. K. M. Clayton for publication as Plate 18 of the Oxford *Atlas of Britain*, 1963.

The move in Britain to establish a separate soil survey and to carry out detailed studies and mapping on the 6-inch scale developed slowly, but in due course, shortly before the outbreak of the Second World War, a Soil Survey of England and Wales was established, with the late Professor G. W. Robinson as its first Director.

Under the Agricultural Research Council, through the Soil Survey Research Board, the Soil Survey of Great Britain is now engaged in detailed mapping in England, Wales and Scotland. The initial surveys were published on the one-inch scale, and by the end of 1970, eighteen sheets had been issued in the English series, with five more in progress, and ten Welsh sheets were available. Since there are 360 sheets to cover England and Wales it is clear that there is a long way to go. But present policy is to survey and publish on the scale of 1 : 25 000, and in 1970 sixteen sheets in this series had been published. In Scotland, 28 one-inch sheets had been completed out of 131, with work in progress on 21 others. It is also interesting to record that the basis of classification of soils being used for the Scottish sheets differs from that for England and Wales, an indication that modern soil scientists are as yet by no means agreed.

## The soil profile

There is, however, general agreement on the importance of studying the soil profile. The parent material of the soil may be the underlying rock, using the word 'rock' in the geological sense, and independent of hardness. In some cases the soil is simply the surface layer of the rock and the two merge imperceptibly into one another, as for example the soils which overlie river alluvium or clay. But in many cases mechanical weathering has broken up the underlying hard rock into smaller fragments, and chemical weathering due to the solvent action of rainwater has played its part. On almost all slopes there is soil creep, the soil sliding or being washed downhill, so that especially towards the lower slopes of valleys there is a layer of transported material from a few centimetres to several metres in thickness between the soil and the underlying rock, and it is this hillwash which forms the true parent material in the soils.

The normal climatic conditions in Britain result in the differentiation of three layers, or horizons. The upper, or A, horizon is subject to downward washing or leaching; the finer material is washed down mechanically and soluble constituents are gradually removed in solution by the percolating waters. The result is to leave a greyish or whitish layer of insoluble quartz sand or rock fragments. Between this whitish layer and the surface there may actually be two thin levels, that at the surface ($A_0$ horizon) being dark or almost black and owing its colour to remains of vegetation, humus and sometimes to sooty material from forest or heath fires. Below this the $A_1$ horizon, though suffering from leaching, remains dark because it receives from above the addition of organic matter. Then follows the main leached

$A_2$ horizon. Below the A horizon is the B horizon often stained brown from oxides of iron, redeposited by the percolating waters from above. The iron oxides may actually form concretions or even cause the consolidation of the level to form a hardpan. The fine mineral particles washed down from above may cause this B horizon to be quite different mineralogically from that above. The C horizon is that of the weathered parent material.

This division of the soil profile into A, B, and C horizons is characteristic of the great world soil group known as the podzols. It may be regarded as normal in Britain in all but the wettest parts where there is impeded drainage and perhaps the drier parts of the east. Actually the podzol profile is broken up wherever the land is ploughed and is therefore seen developed naturally only in sandy heathland or under coniferous woodland. In wet regions such as the level floors of valleys the permanent water table is near the surface and the horizons are somewhat different. Again the surface, or A, horizon may be leached but the intermediate, or B, horizon is saturated for part of the year and relatively dry for the other. As a result oxidation and reduction alternate, producing a characteristic mottling of grey or yellow or brown which is a sure sign of impeded drainage. Below it in the C horizon air cannot penetrate and the conditions are permanently reducing so that greys and blue greys predominate. This is the characteristic profile of the gley or glei soils, though some writers restrict the term gley to the mottled horizon.

In the drier parts of southern and eastern Britain there is less difference between rainfall and evaporation and leaching is less intense. In certain summer months evaporation may even exceed rainfall. It is here that deciduous woodland normally predominates and the annual leaf fall provides a surface layer of brownish humus in contrast to the acid black humus of the podzol. The bleached $A_2$ horizon of the typical podzol is absent, its A horizon differing little in colour from the B horizon, which is rich in flocculated iron, commonly yielding a good crumb structure. Such soils are commonly known as brown earths or brown forest soils and the effect of ploughing and cultivation is normally to promote the development of a soil of brownish colour and to prevent the development of a podzol.

It may thus be said that there are three major soil groups present in Britain—the podzols, the brown earths and the gley soils. Under special local conditions other groups such as peat soils or fenland soils may be present whilst in the hills and mountains the weathering of the old rocks has not proceeded long enough to provide the necessary basis for a proper soil profile. In such areas the so-called skeletal, immature or *azonal* soils (including lithosols) are found. In other cases the surface layers may be washed away with the result that some soils are described as having a truncated profile. Some very interesting soils occur on limestones, particularly chalk. Although there is always an excess of lime in the subsoil, B and C horizons, the surface layer may be so leached as to be even acid in reaction.

## Soil series

Within the great world soil groups one of the most commonly used units of classification, comparable perhaps with the genus amongst plants or animals, is the 'soil series'. This is defined as 'a group of soils derived from the same or similar parent materials under similar conditions, and showing similar profile characteristics'. It is the soil series which is now commonly mapped in detailed soil survey, and the series are named very often from localities where they were first studied—and the series names are unfortunately not, therefore, descriptive. Soil series commonly contain several soil types which are differentiated mainly on the basis of texture. For example, we may speak of the 'Ashley sandy clay loam'. It should be noted that a soil series may include a considerable range of texture and may also include shallow or deep phases so that from the point of view of cultivation a single soil series may embrace land of very different quality agriculturally.

The description of each soil series is based on the character of the profile. Since ploughing and cultivation generally prevent the formation of a profile it is somewhat difficult to fit agricultural soils into this classification. Consequently there is much still to be said in favour of the older approach to the study of soils which was concerned particularly with the texture, the structure, and the chemistry. The Scottish surveyors still recognise the overriding importance of the geological background and are grouping their soil series into associations which have a close relationship to the underlying geology. In England and Wales on the other hand the surveyors are mapping soil series and do not recognise the same type of grouping into associations.

As no detailed soil survey has been carried out over the greater part of the British Isles to date, efforts to show British soils on small scale maps leave much to be desired. An attempt was made by H. Stemme in his *Soil Map of Europe* (1927). This map is useful as a first approximation, but has been severely criticised. It was revised with international collaboration in 1958–62 under the auspices of FAO (scale 1 : 1 m)—see p. 116.

We may now proceed to look at British soils from what may be called the older point of view.

Broadly speaking, it may be said that four factors have determined the distribution of the different types of soil in the British Isles.

1. *Parent material, including solid rocks and drift.* We have seen that five-sixths or more of the British Isles were at one time or another covered by great ice sheets, that the ice sheets removed soil from huge areas, mixed fragments of rock of very varying character, and eventually distributed over the surface of the land a mantle of deposits of very varying thickness which are collectively known as drift. Quite a large proportion of these drift deposits were further resorted by water action—in some cases by waters derived from the melting of the ice, in other cases by more recent streams.

It may even be that some of the finer particles were partly resorted by wind or by wind and rain. What is of fundamental importance is that these surface deposits are very widespread. The geologist who is concerned mainly with the structure of the earth's crust tends rather to regard these mixed drift deposits as of little importance, very often as a distinct nuisance in that they obscure the character of the underlying solid rocks. It is perhaps significant that there is not in existence at the present day a complete one-inch map of Great Britain showing the distribution of drift deposits, and for Ireland the only complete map is an old one by Sir A. Giekie, made many years ago on a scale of 10 miles to 1 inch. Because of the absence of a general drift map of Great Britain the geographer is too often thrown back on the solid geological map, and it is a fundamental, but very common, error to suppose that this is a satisfactory basis for studying the soils of England, Wales and Scotland. In the southern counties, which were little affected by glaciation, this may sometimes be the case, but north of the Thames it certainly is not.

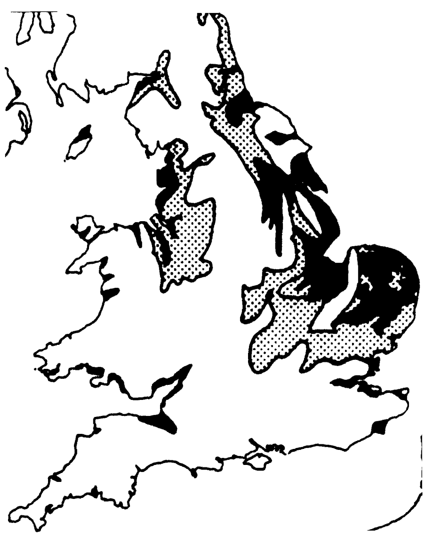


FIG. 72. The drift-covered areas of England and Wales

The stippled areas are almost wholly drift covered: the black areas would be submerged if the drift and later deposits were removed (after L. J. Wills and G. W. Lamplugh). For greater detail the reader is referred to Plate 18 of the Oxford Atlas of Britain 1963.

Where drift deposits are absent, or where the drift is very thin, then the character of the underlying rocks is of the greatest importance in determining the type of soil. Thus the stiff Weald Clays give rise to the stiff clay soils of the Wealden area, the sands of the Lower Greensand to sandy soils, and so on; but it is a mistake to pay too much slavish attention to the geological map, for the poorer siliceous soils of the Highland belt, as for example of

Wales, vary but little in character whether they are derived from Cambrian, Ordovician, or Silurian rocks, although there may be considerable variation *within* any one of these groups or in rocks of the *same* age in different parts of the country.

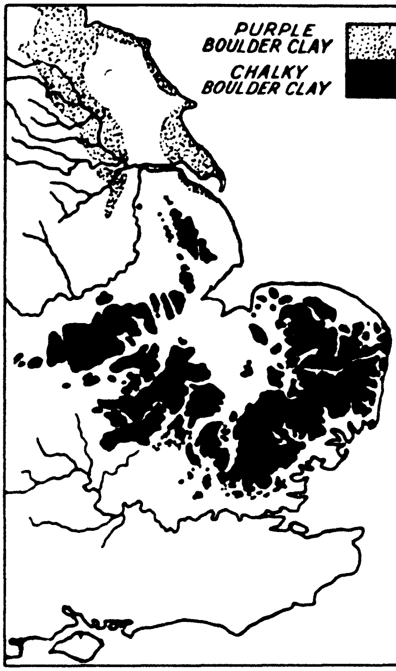



FIG. 73. The principal boulder clays of eastern England (after F. W. Harmer, *Geology in the Field*)

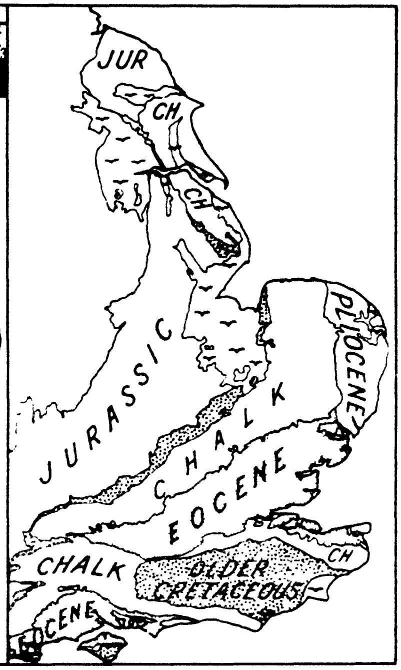



FIG. 74. The solid geology of eastern England

2. *Climate*, including soil climate. On the whole, of course, there is a general increase in the amount of rainfall as one goes from east to west in the British Isles. On the whole there is a general tendency for peat formation to increase as one goes in the same direction. An important point, not always realised, is that one must regard the rainfall of a considerable part of the British Isles as excessive; even if drainage operations were undertaken it is likely that the climatic conditions are such that the soils would not even then be suitable for arable farming. This applies, for example, to many parts of the Highlands of Scotland.
3. *Vegetation*, including former vegetation. The former vegetation cover of numerous areas plays an important part in the character of the soil which is found at the present day.
4. *Relief*. The degree and direction of the slope of the land is important in its relation to drainage.

It has been found that a distinction must be drawn between the texture of a soil and the structure of a soil. When organic matter has been eliminated it is possible, as indicated above, to separate the mineral particles of the soil according to size, that is to determine differences in texture.

If however we take an ordinary worked agricultural or growing soil, dry it thoroughly and, say, place some in a closed jar, it is found that the particles remain grouped together and give the soil what is commonly called a 'crumb structure'. The soil does not immediately break down into a powdery mixture of large and small particles. This crumb structure is recognised as being of enormous importance where growing plants are concerned, and the maintenance of a good crumb structure is what the farmer understands by 'keeping the soil in good heart'.

Certain modern methods of soil treatment, notably the patented substance known under the trade name of Krilium, aim at creating a suitable crumb structure in heavy soils which are otherwise almost amorphous clay.

A great deal of nonsense has been written about the relative value of artificial or chemical fertilisers which add to a soil the chemical nutrients required by plants, and natural or animal manure. There are those who go so far as to say that for good health vegetables and fruits must be grown on land enriched with natural manure. Whilst it is difficult to substantiate such an extreme point of view it is probably true that animal manure helps to maintain the crumb structure of a soil whereas that crumb structure may be broken down by the addition of chemical fertilisers alone.

## Classification

We may now attempt a classification of British soils, especially in relationship to their effect on agriculture and the natural vegetation cover. Two broad groups are to be distinguished:

(*a*) Mineral soils. Those which owe their principal characteristics to the size and character of the mineral particles present.
(*b*) Organic soils. Those whose dominant characteristics are determined by the character and relative quantities of organic compounds present.

### Mineral soils

Apart from the presence or absence of calcareous material, the properties of mineral soils are determined largely by the proportion of particles of different sizes. For purposes of study particles have been grouped arbitrarily under the following types:

Diameter above 2 millimetres—stones.
Diameter between 0.2 and 2 millimetres—coarse sand.
Diameter between 0.02 and 0.2 millimetres—fine sand.
Diameter between 0.002 and 0.02 millimetres—silt.
Diameter below 0.002 millimetres—clay.

*Sandy soils* usually contain more than 60 per cent of coarse and fine sand and less than 10 per cent of clay. Owing to the large size of the particles they present but a small surface for retention of water; they are easily permeable by air and also by water, and hence plant roots can not only penetrate such soils easily but can also 'breathe' easily. Water may drain rapidly away from the roots so that plants may suffer from drought. Not infrequently they are deficient in plant foods because the freely moving water dissolves the nutrients and removes them. For that reason they are called 'hungry' by the farmer, but they are easily cultivated.

*Loamy soils* contain a smaller percentage of coarse and fine sand, but a larger proportion of silt and clay. They are less easily permeable, but sufficiently so to allow the ample aeration of roots and to prevent waterlogging. Thus loamy soils are suitable for all types of crops and are the most valuable of the mineral soils.

*Clayey soils*, or clays, containing a high proportion of clay, are much less permeable, liable to become waterlogged, very sticky when wet, but hard and difficult to cultivate when dry. It is usually difficult for plant roots to penetrate clay soils, and in the summer months when the clay soil is dry and cracked the roots may be torn asunder. They are thus not naturally very suitable for arable cultivation (though they can be much improved by liming and addition of organic matter) and in Britain are very largely given over to permanent grassland. Many of the 'marginal lands' of Britain, once cultivated, but where now cultivation is uneconomic, have clay soils.

*Calcareous soils*. Calcium carbonate and calcium phosphate are both of vital importance to a plant, and in small quantities they usually tend to improve the character of any soil, especially a clayey soil. The term marl is variously applied in Britain, but is sometimes, and rightly, given to a loamy soil or a clayey soil which has a considerable proportion of calcareous material. In soils derived directly from limestone such as chalk, the proportion of calcium carbonate may naturally be very high. On such soils occur plants which are definitely calcicolous, or lovers of lime, whilst on other types of soil calcifugous plants, or haters of lime, occur—especially on acid soil types. It may be noted here that in some cases the soils found in limestone areas are curiously deficient in calcium carbonate, the whole of it having been leached out by the solvent action of percolating rainwater.

*Other types*. Mention should also be made of those soils which have special characteristics due to the presence of quantities of salts—for example, the salt marshes—and a separate category must be preserved for rocky soils or hard rock, not covered by loose earth or by soil in the generally accepted sense.

## Organic soils

*Fenland, or black earth, soils*. The organic matter in soils is, of course, derived mainly from plants. When plants die the very varied organic compounds

of which they consist are very rapidly attacked by the various micro-organisms in the soil which tend to break them down again into simple compounds, such as carbon dioxide, water and ammonia, the ammonia rapidly becoming oxidised to form nitrates. But there are other organisms in the soil which build up their own substance and also reconstruct complex organic compounds. In a well aerated soil a great variety of micro-organisms is present, giving rise to innumerable substances of organic origin, varying

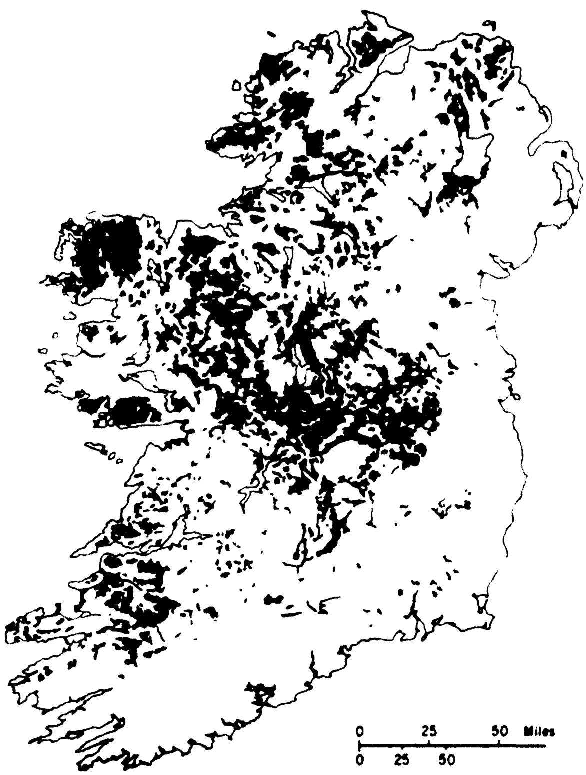



FIG. 75. The peat-bogs of Ireland

All areas in solid black are covered with peat and bogland. The predominance in the Central Lowland and in the West should be noted. For the utilisation of peat see p. 328.

from the complex organic compounds formed by the decaying plants themselves to the simpler compounds and elemental substances which result from their final alteration. Among the most characteristic of the intermediate products present are those compounds, usually black and sticky, collectively known as humus. They are colloidal like clay, but, unlike clay, they do not make the soil sticky; on the contrary they render it more friable. A loamy soil with a good proportion of humus may be described as the most fertile of all soils, and where the Fenlands of England have been drained are some of the most fertile agricultural lands anywhere to be

found; it will be noticed that the characteristic colour of the soil is almost black, due to the large proportion of humus present.[1] Where, however, the aeration of the soil is deficient, usually due to the excess amount of moisture, then there tends to be an accumulation, not of humus but of humic acid.
*Peaty and moorland soils.* In peaty and moorland soils the great defects are acidity due to the excess of humic acid and poor aeration, in turn due to excessive moisture and low temperatures. In some cases by draining, or by the admixture of a proportion of calcareous material, a peaty soil may be converted into a very rich humic soil; but there are other areas where the acidity is so great that the expense of treatment is prohibitive even by these simple means. This, of course, is particularly the case in moorland areas where the drainage is bad.

Perhaps a better classification of organic soils would be:

*Mild humic soil* or mull, such as is normally found on the floors of deciduous woods, in meadows, gardens, etc., and has a neutral reaction or is only slightly acid or alkaline, being well aerated by earthworms, etc. (brown earth).
*Fen or mild peat*, formed where there is an excess of water but a deficiency of oxygen, as on the margins of lakes; but the water gives an alkaline reaction because of the presence of lime or other bases in quantity. When drained this is the rich humic or the black soil of the Fenland area.
*Raw or acid humus* is formed on soils deficient in lime and is characteristic of podzolised soils under coniferous woodland and on dry heaths. Oxidation is not necessarily deficient, but the soil must be so acid that the humus is unsaturated and earthworms are absent.
*Acid peat.* Under conditions of excessive moisture, low temperature and oxygen deficiency acid peat accumulates and a pure peat soil is produced. If the conditions are maintained this acid peat soil may reach a great depth giving the characteristic moor ('mor') soil with moorland vegetation.

# The distribution of soil types in the British Isles

## Mineral soils derived from drift deposits

The deposits left behind after the retreat of the ice sheets of the great Ice Age vary enormously in character. The following broad types of soil derived from these and other superficial deposits may be distinguished:

*Boulder clay.* This is usually a stiff clay with numerous boulders of rock of very varied size transported from a distance. As a rule the soils derived from boulder clay are stiff heavy clay soils and hence little cultivated but rather left as grassland. In the wetter parts of Scotland and Ireland particularly

1. Though humus is dark in colour some of its constituents are not.

they tend to be waterlogged and to give rise to acid humus soils or acid peaty soils. The same happens with compact soils even if not true clays.

*Chalky boulder clay.* A special place must be made for the boulder clay, common in parts of eastern England, where there is a considerable admixture of chalk. This ameliorates the normal character of the clay soil

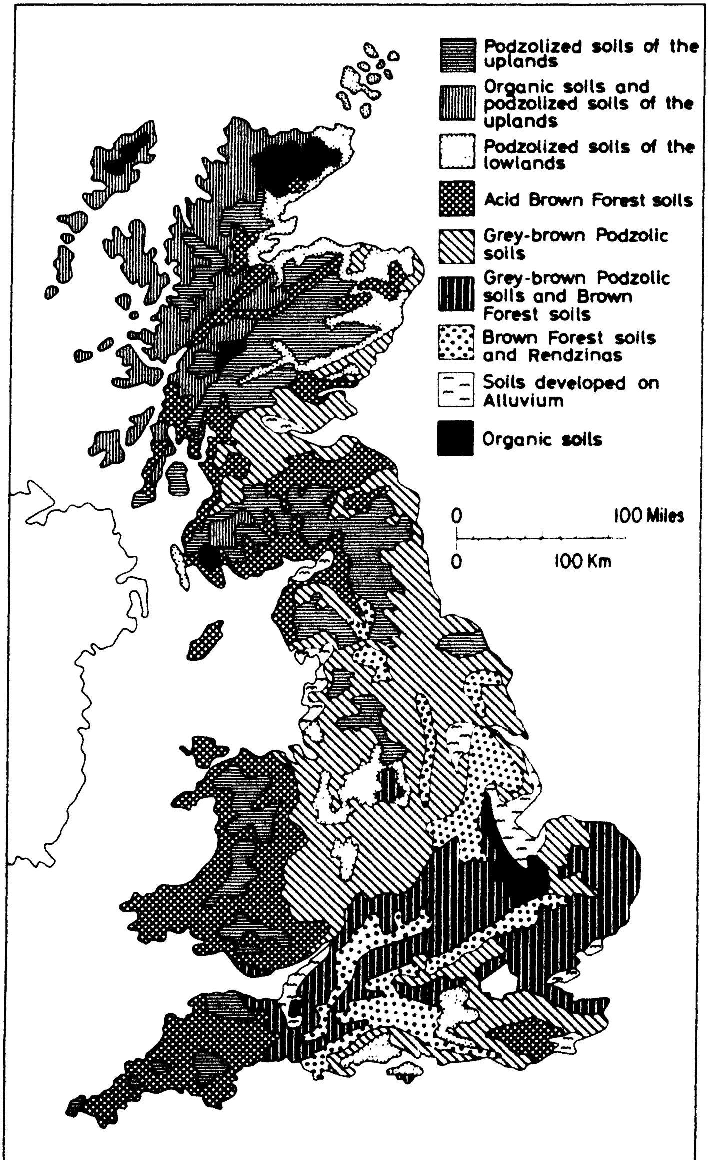



FIG. 76. The main soil groups in Great Britain

From information supplied by the Director of the Soil Survey, from the British contribution to the soil map of Europe (see p. 116).

derived, and the chalky boulder clay is frequently very fertile (see p. 256).

*Loamy glacial drifts*, such as those derived from the Old Red Sandstone in Scotland and in parts of England. Because the soils are well mixed they may be very fertile and hence the land is largely cultivated. This is the case in the Lothians of Scotland around Edinburgh.

*Glacial sands.* Particularly conspicuous in Ireland are the dry grass-covered gravel ridges, known as eskers, and the sandy, loamy or stony, sometimes clayey, knolls of glacial drift called drumlins. Where the sands are coarse and the water drains away quickly the soils are light and sandy, but the drumlins are often selected in Ireland for agricultural purposes because of the better drainage when compared with the low-lying levels by which they are surrounded.

*Brick-earth.* In the south of England there are some fine loamy or silty soils which are derived from what is commonly called brick-earth. Brick-earth (cf. French *limon*) seems to be in the main composed of the finest particles which result from glaciation, probably distributed partly by wind and thus corresponding to loess, but resorted under conditions of heavier rainfall in England, and so differing in character from typical loess. Soils derived from brick-earth are very fertile.

*Gravelly soils.* There are numerous sheets of gravel both at high levels and at low levels, particularly in England, some of which may be derived from outwash fans when the ice had melted, others of which are the normal deposits of rivers and some perhaps coastal deposits laid down under marine conditions. The high level gravels often give rise to infertile soils whereas the low level gravels, especially if covered by a thin layer of brick-earth, may be particularly fertile. Special reference will be made later to cultivation on such areas as the Thames terraces.

*Clay with flints.* A special type of deposit is widely distributed on the surface of the Chalk Downs, especially the North Downs of Kent. It consists of a stiff clay, brownish in colour, with sharp angular flints—a residual deposit from weathering of chalk. All the lime has been leached out so that it is a stiff clay soil deficient in lime, commonly, therefore, left to grassland or to damp oak woodland contrasting with the surrounding chalk country itself.

*Alluvium.* The fine grained deposits of the alluvium of flood belts and riverine tracts need no further description, except to point out their wide distribution in this country. To them may be added the marine silts such as are important round the Wash.

## Mineral soils derived from the underlying solid rocks themselves

Two broad divisions may at once be distinguished:

(*a*) The siliceous soils derived from the older rocks, mainly Paleozoic rocks, of the 'Highland Zone' (see p. 26) of the north and west of England and Wales, Scotland and Ireland. Although technically they may be classified

into sands, loams and clays, according to the size of the particles, they tend to differ from the better known soils derived from later rocks in the southern and southeastern parts of England. They are comparatively well drained, but usually lack the fertility of soils derived from later rocks because the weathering processes have failed to form soils of great depth. Where drainage is bad and moisture excessive peat and moorland soils predominate, as, for example, in many parts of the Highlands of Scotland. Indeed the soils of Scotland derived *directly* from underlying solid rocks seem to be limited. Among the soils derived from the Paleozoic rocks are extensive stretches of limestone soil, as in parts of the Pennines.

(*b*) Soils derived from the younger Mesozoic and Tertiary rocks of the 'Lowland Zone' (see p. 26) of the south and east of England. Of the Secondary rocks the marls of the Trias and the clays of such belts as the Lias and the later Jurassic rocks, the Cretaceous of the Weald and the Tertiaries (e.g. London Clay) give rise to tracts of heavy clay soil. Between these there are the ridges formed by the outcrops of sandstone and limestone. On these will be found sandy soils, as on the Lower Greensand, and the calcareous soils characteristic of the Oolitic Limestone and of the Chalk. Again, it must be remembered that on these limestones, including the Chalk, leaching is often important and lime may be practically absent. What is often important is the rapid and very marked local variation in many parts of the Lowland Zone, e.g. the London Basin.

### Organic soils

The distribution of organic soils in the British Isles will have been made clear from the descriptions given above.

## International Soil Map of Europe

### The British contribution to the United Nations (Food and Agriculture Organisation) Soil Map of Europe, 1961–63

As indicated in the preceding pages there is far from being general agreement on soil classification. What has been said of British soils is factual and non-committal. For purposes of the International Soil Map of Europe, the British Soil Survey drew a small-scale map (1 : 2½ m) which showed, apart from soils developed on alluvium and the organic soils of upland peats and lowland fens, six categories (Fig. 76):

1. Podzolised soils of the uplands—the highlands of Scotland, Pennines, Lakes, Wales, and the southwest—with patches of peat.
2. Podzolised soils of the lowlands, mainly in the northeast of Scotland but including the coarse sandy lands of England in the Hampshire basin, Bagshot country, etc.

3. Acid Brown Forest soils, dominant in Wales, the southwest peninsula, and the wet southwest of Scotland.
4. Grey-Brown Podzolic soils, found over much of the Midlands of England and the Central Lowlands of Scotland.
5. Grey-Brown Podzolic soils and Brown Forest soils mixed, over much of southeastern England.
6. Brown Forest soils with Rendzinas (chalk and humus-rich soils lacking a B horizon), on the main limestone areas of the Cotswolds and chalklands.

# 7
# The natural vegetation of Britain

It is frequently stated that except for areas of fenland and marsh the natural vegetation of the whole of the British Isles was forest or woodland, and the small extent of woodland at present remaining—only about 6 per cent of the surface of the whole country—is frequently quoted as evidence of the extent to which man has cleared the natural vegetation of the country and artificially altered the appearance of the surface. While it is perfectly true to say that natural woodland has been cleared over vast areas—as, for example, over the Weald of Kent, Surrey, and Sussex—it may be that there is a tendency to exaggerate the former extent of forest land in the British Isles as a whole, and to ignore other types of natural vegetation. Further, when one is discussing the former extent of natural vegetation it is necessary to say exactly to what period one is referring. Before dealing with the different types of vegetation which may be found in the country at present, it will be useful to outline the changes which one may postulate as having taken place since the close of the great Ice Age.

It has already been pointed out (p. 22) that during the great Ice Age ice sheets covered Great Britain as far south approximately as a line joining the Thames and Severn, and also the whole of Ireland, with the exception possibly of certain tracts in the south. Whatever may have been the preglacial vegetation of the British Isles, it is clear that the conditions prevailing in the south of both Britain and Ireland at the time of the maximum extension of the ice sheet (the Lowestoft or Elster Glacial, cf. p. 24) must have been the conditions of the tundra lands. With the final retreat of the ice after the last or Weichsel Glacial and the amelioration of climatic conditions Britain was gradually recolonised by plant species from the continent, that is from the south and east. Indeed, there are numerous species still restricted to the south and east, and on the whole the flora of the British Isles becomes poorer in species as one goes northwards and westwards. Just as in northern Russia and Finland at the present day, to the south of the tundra belt the dominant trees of the great forests are birch and pine, so we have good evidence that as the ice finally receded in Great Britain these were the first trees to invade the country. The analysis of pollen in the successive layers in peat deposits—work associated especially with the name of Dr H. Godwin—has enabled an exact sequence to be worked out and this is summarised in the table on p. 86.

After the early postglacial birch–pine forests (Zone IV of Godwin) pine became dominant (Zone V), then pine with hazel (Zone VI). This was throughout a period with dry cold winters (the Boreal Period) when Britain was probably still joined to the continent and was inhabited by Neolithic man--using polished stone implements. The submerged forests round the coasts of Britain are largely of this age. There seems then to have been quite a sudden change to wet, mild conditions (the Atlantic Period) which may be due to the final severance of Britain from the continent and the establishment of the present system of oceanic circulation. The change was marked, probably about 5000 B.C., by a great development of oak but in association with alder, elm and lime (Zone VII), and later with alder, elm, birch and beech (Zone VIII). During these periods Neolithic culture gave place to Bronze Age and then Iron Age man.

It is still uncertain how far north some of the invading trees and other vegetation extended, but in Iron Age times, shortly before the Roman invasion and the Christian era, we can picture the British Isles as for the most part forest-covered, the types of forest present being determined by climate and by soil, and ranging from forest in the north, in which the Scots pine and birch were dominant, to the great stretches of oak woodlands on damp soil in the Midlands and south, and to the beech and hornbeam forests of the drier areas in the south.

The forest cover may have been interrupted over wide tracts by other types of natural vegetation. Fenland and freshwater marshland probably covered very large areas, such as in the region still known as the Fens, of which a description will be given later. Proofs exist that much of the heathland and moorland of the present day was formerly forested, but this may not apply to the whole of the great areas that are now moorland. Scrubland, which can be defined as the transition phase between grassland or heathland and forest, may also have covered very considerable areas. It is much more difficult to assess how far grassland may be regarded as a natural type of vegetation in Britain. At present there are three or four kinds of grassland which correspond broadly with the main types of forest. Thus the chalk or fescue grassland which is characteristic of the shallow soils derived from the chalk corresponds with the beech forests found on the same soils. These chalk grasslands may have been typical sheep pastures from very early times, whilst more recently the ravages of rabbits and other small grass-eating animals have contributed to prevent the growth of forest on these upland tracts.

It may have been the more open character of the vegetation on the higher limestone tracts made them attractive to the Neolithic settlers. There is no doubt that the Neolithic settlements occurred in such areas, and early Neolithic roads are found for the most part on such elevated tracts, despite difficulties of an adequate water supply (see Chap. 24). Another type of grassland, often called grass heath, occurs on sandy soils and shows many transitions to and from heath proper. A third and very common type of

grassland is that which is called neutral grassland, and which corresponds to the oak forests of the heavy clay lands. This on alluvial soils, or where the water level is high, passes naturally into waterside meadow, corresponding broadly with the willow and alder woodlands.

There can, however, be little doubt that most of the grassland of the present day owes its character to human influence.

An attempt will now be made to describe very briefly some of the more important types of the natural and seminatural vegetation which are found at the present day in the British Isles. Before doing so it will be well to understand the principle involved in plant succession. Each type of physical environment, that is each combination of climate, soil, etc., may be regarded as having an association of plants peculiar to itself, and this plant association would form the natural vegetation cover, provided interfering factors are absent. This natural vegetation association is known as the climax association, but it must not be supposed that a tract of country such as Britain must have been when the ice sheet left it, or a tract of land which has been cultivated by man and then deserted, will immediately become covered with the climax vegetation. It is instead invaded and colonised by plants whose dominance is limited in that they will in time become ousted by others until the climax community eventually establishes itself. Thus the natural vegetation cover passes through a succession of stages; owing to the depredations of animals such as rabbits, the interference of man and his domestic animals, certain of the stages in the plant succession may become quasipermanent, and the climatic climax may not have an opportunity of establishing itself at all.[1] Thus in attempting to describe the natural vegetation cover of the British Isles we shall be dealing with various stages in the plant succession as well as climax communities.

Referring to the table given on p. 149, showing the utilisation of the surface of the British Isles, we may regard natural and seminatural vegetation as embracing the first two categories – namely, the woods and the rough grazing land, which broadly speaking is moorland and heathland, and at least to some extent the permanent pasture – whilst under the heading of other lands are included certain areas of marsh, etc., which are definitely natural vegetation.

## TYPES OF NATURAL VEGETATION

The following brief account of the chief types of natural vegetation found in the British Isles has been based in part upon the standard work on the subject, *The British Islands and their Vegetation*, by A. G. Tansley. The types have been arranged in the following summary under the three broad headings of forest and woodland, heathland and moorland, and grassland, and

1. Reference should be made to the important studies by Dr E. Wyllie Fenton, *The Influence of Man and Animals on the Vegetation of Certain Hill Grazings in South-East Scotland*, Edinburgh School of Agriculture, I and II, 1951–52.

thus correspond with three main categories which were distinguished in the maps of the First Land Utilisation Survey of Britain. Thus the types described under the forest and woodland will include the principal types of natural vegetation to be found in those areas coloured dark green on the Land Utilisation maps. Similarly the type described as heathland and moorland will be the types which make up the areas of yellow colour on the map, whilst the types described under grassland will be those which correspond to the light green areas on the Utilisation maps.

## Forest and woodland

### Damp oakwood or pedunculate oakwood

In more ways than one the oak is the characteristic British tree, and there can be little doubt that the whole of the lowlands of Britain with clayey or loamy soils were at one time covered with oak forests. Most of the woods still existing on these soils, with the exception of those, of course, planted with exotic species, are also oakwoods or derived from oakwoods. The dominant tree of the heavier soils and those well supplied with mineral salts is *Quercus robur* (*Quercus pedunculata*), or the pedunculate oak. Most of the British oakwoods have been heavily exploited for timber in the past.[1] Oak was in special demand for shipbuilding before the extensive use of iron and steel. The rise of the English Navy and Mercantile Marine coincided with a rapid using up of extensive oak forests, particularly in the southeast of England, where the oak forests were within easy reach of navigable waters and harbours. During the Middle Ages, too, when most of the iron was smelted by means of charcoal, there was an enormous destruction of oak forests. It is of course well known, as explained elsewhere in this book, that the disappearance of the Wealden iron industry was not due to the exhaustion of the ore, but to the virtual exhaustion of the supply of wood for charcoal. Most of the oakwoods which remain have been sadly neglected from the forestry standpoint and really good standard trees, suitable for the production of timber, are few. In the south and midlands of England the majority of oakwoods are now in the form of coppice with standards. That is to say there are some eight to a dozen 'standards' or large trees per acre, while the intervening area is occupied by 'coppice', trees of other species. By far the most common of coppice trees is hazel. The tree is cut near the ground and the stump sends up a number of shoots. After a period of ten or fifteen years the main branches thus formed are cut for the provision of fencing posts, etc., the smaller ends having a small market as bean sticks and pea sticks. Ash and birch are also common in coppice woods, and oak itself may be coppiced, in addition to the oaks which grow as the stan-

1. Primitive woodland can frequently be distinguished even from very old plantations by a greater richness in plant species of the ground vegetation.

dard tree. Another important coppice tree is the Spanish chestnut, much favoured for fencing because it splits evenly into two half-round sections. It is urged by some that these woodlands of coppice with standards are legacies from the Middle Ages when the oak woods were thinned in such a way that the remaining trees branched freely and thus gave a supply of curved timber and 'knee' pieces which were particularly useful in shipbuilding; obviously quite contrary to the usual requirements of modern industry of good straight timber. The copse or coppice with standards will clearly present a very different appearance shortly after it has been cut, and a recently cut woodland is usually characterised by a rich growth of ground plants, including the favourite primrose and bluebell. These almost disappear as the coppice trees once more grow up and cast a greater shade over the ground. The wood anemone and dog mercury are other characteristic ground plants. 'On the edges of burnt oakwoods which have been carelessly exploited a scattered scrub is commonly found with spaces of turf between the clumps of bushes and an occasional isolated oak tree. This vegetation represents degenerate oakwood from which the trees have nearly all quite disappeared.' Many of the species present in this scrub are spiny species, and this is doubtless due to the fact that they are protected by their spines from browsing animals. This kind of land is occasionally used for pasturing, but has economically no value as woodland (recorded by the Land Utilisation Survey as Fc).

### Dry oakwood

Oakwoods also occur on dry sandy soils. The oak may either be *Quercus robur* or *Quercus sessiliflora*, or the two may be mixed. Birch is usually found in the dry oakwoods in varying proportions, but the hazel and the ash are commonly absent. The ground vegetation is often poor, but a common feature is the presence of large quantities of bracken. The beech may occur, particularly in societies or clumps, and as usual in beechwoods the undergrowth is here almost absent. Scrub may occur on the margins of these dry oakwoods, and the woods, especially oak with birch, often grade insensibly into heathland. As Tansley points out in his later writings there is no fundamental difference between damp and dry oakwoods. Reference will be made later to the oak–birch heath.

### **Sessile oakwoods** (Durmast oakwoods)

On the older rocks of the British Isles, which, as already described, furnish poor siliceous soils, oakwoods again occur, but here the dominant tree is the Durmast oak, *Quercus sessiliflora*. The soils are shallow and are usually deficient in soluble salts, especially calcium, and often show a marked tendency to allow the accumulation of acid humus. Durmast oakwoods occur, however, on a great variety of soils, but always with soils poor in mineral salts. The trees are therefore on the whole of small dimensions;

where larger, the trees are of a more upright habit[1] than *Q. robur*. The birch (*Betula tomentosa*) commonly occurs, the beech is sometimes found in larger woods. Conifers are not indigenous, but both the larch and the Scots pine are commonly planted. The holly (*Ilex aquifolium*) is usually found in the oakwoods on the Pennines. On the hills such as the Pennines and in Wales, it would seem that these oakwoods formerly extended to higher levels than at the present day. They tend to degenerate now into scrubland and there is every passage from scrub to grassland and moorland. In the intermediate stages, especially on the drier soils, bilberry and bracken are very common. In the Pennines and drier regions the ash is usually confined to wetter situations and the sides of streams, but in the regions of the British Isles which have a heavy rainfall, for example in the Lake District, most of the oakwoods contain a very large proportion of ash, and one really has an oak-ash woodland. The same is true, for example, of some of the Devonshire woods.

## Birchwoods

Anyone who knows the great northern forests of Russia and Lapland will know the extent to which the birch is there intermingled with hardy coniferous trees. It is not, therefore, surprising to find a fringe of birchwood occurring above oakwoods in the British Isles, and forming in the Highlands of Scotland characteristic woods at the sides of the valleys, sometimes even occurring up to 600 metres (2000 ft). The birch is a light demander, but can stand great exposure. Because Scots pine thrives under much the same conditions, birchwoods and pinewoods are largely interchangeable. Oakwoods from which the oak has been removed are often replaced by the less valuable birches and become birchwoods, whilst wood clearings often seem to pass into birchwoods rather than back to the original oakwoods. Thus the birchwoods may replace the oakwoods or may occur definitely as a vegetation layer above them.[2]

## Pinewoods

Although the Scots pine (*Pinus sylvestris*) was formerly native in many parts of England and Ireland, it is generally agreed that it disappeared from the south of England, and has only recently been reintroduced (in the eighteenth century or perhaps earlier). In Scotland pinewoods at one time covered large areas in the broad valleys or straths of the Highlands and the

1. These oakwoods may be coppiced on a twenty-year rotation.
2. It has been pointed out by Sir E. J. Salisbury that primitive man, working with stone tools, would find the birch easier to cut down than oak, and it may be that he was attracted to higher ground in many parts of Britain not because the ground was already clear but because the birch forest was more easily cleared.

glens, extending for considerable distances up the mountain slopes. Owing to heavy exploitation the area occupied by these pine woodlands is now rather seriously restricted. On its introduction into the south of England the Scots pine spread very rapidly over tracts of sandy soil, and it now forms extensive subspontaneous woodland, as on the Bagshot Sands of the London Basin and on the Lower Greensand of the Weald. But whether in Scotland or in the south of England, there is a very close association between pinewoods and heathlands, and it is often difficult to decide whether an area should be classified as a pinewood, or as heathland with many scattered pines. It will be seen that on the dry soils of the south these pinewoods are competitors with dry oakwoods and with beechwoods. The close pinewoods are very poor in other species, partly on account of the deep shade and partly because of the thick layer of pine needles which carpets the floor of the woods. Where more open, bracken is common, whilst over large areas the bilberry (*Vaccinium myrtillus*), as in the great coniferous forests of the north of Europe, is very characteristic, associated of course with the heath (*Calluna vulgaris*).

**Beechwoods**

By pollen analysis Godwin has now proved that the beech (*Fagus sylvatica*) invaded Britain in Atlantic times, but afterwards it retreated from the southwest and elsewhere. Because it behaves as a native only in the southeast it was long thought to be a recent introduction. Beechwoods occur characteristically on the chalk, occupying the steep valley sides or the scarp faces on the North and South Downs as well as large areas in the Chiltern Hills and in parts of the Cotswolds. They are absent from the northern chalk areas of Yorkshire and Lincolnshire as well as of Norfolk. On the Continent the beech tends to occur rather on the marly or damper limestone soils. In England the beech is natural to the drier limestone soils, possibly as a result of the generally damper character of the English climate. The way in which the beechwoods occur on the steep sides of the chalk valleys has given rise to the commonly applied name of 'hanger' to this type of wood. The beech is not only the dominant tree in the beechwoods, it is very frequently the only tree, and indeed typically forms pure high forest in close canopy. Shrubs and ground vegetation are scarce, in fact the latter is often quite absent, and the ground covered with nothing but the delightfully brown fallen leaves. Thus, walking through a beechwood, there are many characteristic points of difference to be noticed from other types of English woodland. Occasionally the yew occurs as a shrub in the beechwood forest, and locally the yew has become dominant and forms yewwoods. Beechwoods are not restricted to the chalk; the beech has migrated to lighter sandy soils, much more rarely is it found on heavier clay soils. It is essential that there should be free drainage round the roots. The beech cannot grow with its 'feet in water'.

### Ashwoods

Ashwoods are characteristic of limestone soils in the north and west of England, where, as already pointed out, beechwoods are absent. They are thus well-known features of the limestone dales of the Carboniferous Limestone of Derbyshire and of the Mendips. Wych elms are commonly found in these ashwoods whilst shrubs are characteristically abundant (including a number of species), partly owing to the high light intensity, even in summer, resulting from the translucent canopy of the trees. On marly soils the oak becomes important and one may really distinguish an ash–oak woodland association as characteristic of marls and calcareous sandstones. Again, hazel is common, and where the oaks have been left as standards one may have an ash–oak–hazel coppice, very common indeed in the south of England, especially towards the rather damper west, taking the place of the oak–hazel coppice, which occurs on clay soils that are poor in lime.

### Alder–willow associations

The alder (*Alnus rotundifolia*) and the willows (*Salix*) are the characteristic trees of very damp situations. By the sides of streams in oakwoods the alder usually appears, whilst the alder–willow association is the woodland association which corresponds to marshland.[1] The osier (*Salix viminalis*) is of course usually planted—on tracts of alluvium by the sides of rivers where the surface of the ground is only a few inches above the permanent water level. The ground vegetation in such situations is that of a typical marsh. In the wet areas of East Anglia the woodland formation, occurring associated with fens, is known as swamp carr and marsh carr.

## Heathland and moorland

Under the title of Rough Grazing, Mountain Heath, Moor or Downland, the published statistics of the Ministry of Agriculture, Fisheries and Food include a considerable variety of types of natural vegetation. This category is identical with the Heathland, Moorland, Commons, and Rough Hill Pasture distinguished by the First Land Utilisation Survey of Britain and shown on their maps in yellow.

In 1940 Sir George Stapledon and Mr William Davies extended to England a reconnaissance survey they had previously carried out in Wales and later a map on the scale of 1 : 625 000 was published and is usually referred to as the Grassland Map. It shows, highly generalised and ignoring both woodland and ploughland, lowland grassland divided into eight

1. Sir E. J. Salisbury believes that alder woodland was formerly very widespread in low, damp ground, but, because of the relative ease with which the alder could be cleared by primitive man with stone tools, was largely destroyed at an early date. Compare the early settlements on valley gravels (see p. 642) where the lowland water-side meadows were an added attraction.

categories according to agricultural quality. The heathland, moorland and rough pasture are shown divided into eleven types:—heather moor, heather fell (i.e. with many boulders), lowland heaths; cotton grass and deer-grass moors, molinia moor and nardus moor; mountain or hill pastures and grassland invaded by bracken, gorse, etc; basic pastures of mountains, downland and lowland grass heaths.

This scheme was extended and enlarged for use in Scotland and a map prepared using existing data which was published as one of the National Planning Series (1:625 000 in full colour) with an explanatory text by Arthur Geddes.

It will be found that these schemes agree generally with that given below, based on Tansley.

## Heathland or heath associations

In heathland by far the most widespread and abundant species is ling or heather (*Calluna vulgaris*). With it are usually associated other members of the Ericaceae of which *Erica tetralix* is one of the commonest; whilst towards the north of Britain the bilberry (*Vaccinium myrtillus*) becomes dominant over considerable tracts. Under the dense shade of *Calluna* very few other species can exist. Heathland is usually found on gravelly or relatively coarse sandy soil, or on similar soils derived from the older rocks in the north. The coarse, gravelly or sandy soil usually has a dark surface layer coloured by much humus, below which there is a layer of leached sand, often pale grey, or even whitish in colour. Between this and the unaltered sands below there is frequently a compact stratum of hard moorpan. The moorpan may be only a few inches but perhaps several feet below the surface, but it is this which prevents the invasion of heathland by trees, and heathland in which the hard pan is present cannot be afforested unless the pan is broken up or holes made in it for the roots of young trees to penetrate. Thus the heath association is usually a stable association, either resulting from the final degeneration of the oak–birch–heath association or a stage in the succession on poorer sandy soils.

Where the hard pan is absent there may be every gradation from the pure heathland to the oak–birch association, or to pinewood. It is frequently difficult in studying a tract of country to decide what should be called pinewood with a ground vegetation of heather and heathland with scattered pine trees. Indeed any distinction must be a very artificial one. Gorse is often found on the margins of heathland where conditions are less acid, though it is not essentially a typical member of the heathland itself. Local bogs are common in heathland. Some of the better known regions of English heathland include the stretches of flat sandy country in northwest Norfolk, and southeast Suffolk on the crags or on the more sandy members of the overlying drift deposits. Heaths are well developed on the Bagshot Beds of the London Basin, and on the sandy Tertiary beds of the Hampshire

Basin. They are common, too, on the sandy beds which occur in the Wealden area. Both the sandy soils of the New Forest region and the sandy soils of the Weald afford excellent examples of the way in which heathland dovetails into the oak–birch woodland and pinewood. In the west heathland occurs both on Devonian Sandstones, as on Exmoor, or on the granite masses, such as Dartmoor. Here, being in the wetter part of the country, there is frequently a gradation into true moorland with heather growing on peat. In Yorkshire the name 'moor' is often applied to true heathland, and here varieties have been distinguished according to the dampness of the areas. Heathland in Scotland does not usually occur at greater elevations than 600 metres (2000 ft), and is found in those parts of the Highlands where the mean annual rainfall is comparatively low – less than 1500 millimetres (60 in). The heathlands of the Highlands are usually called moors, and are indeed the typical grouse moors. As such they are systematically burned in rotation every ten to fifteen years. In various regions, the association of bracken with typical heathland should be noticed. Bracken usually indicates a relatively good soil.

## Limestone heathland

In the ordinary way heather is a plant that dislikes lime, and it is therefore not found on calcareous soils. But some plateau areas of limestone, owing to leaching action, tend to lose their lime; in such areas heather may occur, but it is associated with plants which have long roots, and which therefore reach the limestone below and are thus lime lovers. This accounts for some heathlike vegetation occurring in limestone areas. Of rather a different order are the limestone pavements which occur as striking features on some of the summits of the Carboniferous Limestones, as in the north Pennines and in the great limestone plain of County Clare in western Ireland. The exposed surface of the rock is very bare, and although rather rich in mosses it is extremely poor as regards larger plants which are more or less restricted to crevices. Heather (*Calluna*), though a calcifuge, may be present partly because of the existence of little pockets of soil from which the lime has been leached.

## Moorland

Moorland is a comprehensive term, and includes many different types of natural vegetation. Moorland is essentially the vegetation of peaty soils. Frequently the soil is deep, practically pure peat; in other cases there is only a shallow layer of surface peat much mixed with mineral substances from the underlying rocks, in which case there is naturally a transition stage between the moorland and heathland, as one finds in the 'moors' of the North Riding of Yorkshire. There are also peat soils, especially those relatively rich in lime (hence called mild peat) and developed particularly, as far as Britain is concerned, in East Anglia, to which the name black fen

is frequently applied. Separating moor and fen, moor has a relatively wet peat soil of considerable depth, fed by water poor in mineral salts, suffering from lack of aeration so that the humic acids produced give rise to a soil water which is acid in reaction. Fen, on the other hand, has a peat or peaty soil fed by water which is relatively rich in mineral salts, with the result that the ground water is alkaline in reaction. When drained, the peaty soil of the fens gives rise to a very dark coloured but extremely rich soil; whereas even when drained it is difficult to carry out cultivation on many tracts of moorland because of the essentially acid nature of the soil.

In moorland a broad distinction is possible between lowland moors, such as those areas known as 'mosses' in Lancashire, and upland moors. *Sphagnum* is a very common constituent of lowland moors and in the valley moors which occur in the south of England in the wetter parts of heathland. Amongst the different types of upland moor which have been distinguished in the wettest areas there is the *Sphagnum*, or bog moss moor, of comparatively limited extent. The cotton grass moors are characterised by the cotton grass (*Eriophorum vaginatum*) and are much more extensive in their occurrence. Cotton grass moors are widely distributed on the summit plateau of the Pennines, and sections through the peat of these areas show that considerable areas of these moorlands were once forested. *Scirpus* or reed moors occur in the wetter regions of the northwest Highlands of Scotland, as well as in some parts of Ireland, such as the Wicklow Mountains. The dominant plant is *Scirpus caespitosus* with often a considerable quantity of heather. There is evidence that some of these moors, too, were formerly forested, the remains of Scots pine and birch having been found in the peat.

### Bilberry moors

The dominant plant here is *Vaccinium myrtillus* (the bilberry) and this type is common in the Pennines and in the central part of the Highlands of Scotland, but not in the northwest nor the Hebrides.

### Heather moors

These differ from the heathland mainly in the occurrence of a greater thickness of peat, and the frequent association of heather and cotton grass or heath and bilberry.

### Grass moorland

Grass moorlands cover large areas of Boulder Clay, such as in the southern part of the Southern Uplands, and also in the western Highlands of Scotland. The grass moorland tends to be intermediate in character between the *Scirpus* moor, already described, and siliceous grassland. The vegetation is mainly composed of a variety of grasses, rushes and sedges, but as in other moors, the soil is peaty, acid, and generally wet during most of the year.

# Grassland

Five or six main types of grassland may be distinguished and may be regarded as seminatural formations in that they correspond with different types of woodland, and are found where the woodland has been cleared.

## Neutral grassland

The adjective 'neutral' indicates that the soil of these grasslands is neither very acid on the one hand nor particularly calcareous on the other. The neutral grassland is the ultimate phase of degeneration of damp oakwood and so occurs associated with damp oakwood on the same types of soil. It consists of a close turf of grasses with associated herbaceous plants. The plants characteristic of calcareous pasture on the one hand are absent, and so are those which are characteristic of heath pastures. Neutral grassland affords excellent permanent pasture and is usually heavily grazed, but where less heavily grazed, as on the borders of some of the village greens of central and southern England, has many of the plants common to the ground flora of the damp oakwoods, including the anemone and the primrose. Where clay soils are low-lying, and ground water approaches the surface, the appearance of various species of rush (*Juncus*) may be noticed in neutral grasslands and marks a gradual passage towards rough marsh pasture. The line is often very difficult to draw, and this was found to be the case in surveying for the First Land Utilisation Survey. The best neutral grasslands are the permanent pastures dominated by rye grass (*Lolium perenne*) and wild white clover (*Trifolium repens*).

## Acidic grasslands

Grassland dominated by bents (*Agrostis* spp.) together with sheep's and red fescue (*Festuca ovina* and *F. rubra*) probably covers a greater area than any other type of grassland in Britain. It is the typical community of the 'grassheath' and 'siliceous grassland' of earlier writers. Grass heath is associated with dry oakwood. Although transitions to ordinary heath are found, in the grass heath true heath plants, such as *Calluna*, *Erica*, etc., may be, and usually are, entirely lacking; but the grasses are those which prefer a sandy soil and usually form a close short turf. These grasslands are less valuable as grazing lands than the neutral grasslands, and so one often finds patches of gorse coming in on the margins of such areas. The East Anglian heaths sometimes include quite considerable stretches of dry grassland of this character, and it is believed by some writers that they represent a survival of steppe, or semi-steppeland, conditions in Britain. The better 'siliceous grasslands' correspond with the sessile oakwoods which grow on the thin soils of the older rocks. In such areas as the Pennines they tend to occur, not only associated with the oakwoods, but at higher levels.

### Nardus and Molinia moors

On land with poorer soils or more acid conditions, grassland gives place to what is better described as moorland although dominated by grasses. On poorer drier areas the characteristic grass is the mat grass (*Nardus stricta*); whilst on the wetter soils the purple moor grass (*Molinia caerulea*) is the characteristic grass. In the southwest, the characteristic grass is *Agrostis setacea*. The dominance of grass is sometimes interrupted by stretches of bracken, whilst the small gorse comes in abundantly in such areas as the Malvern Hills, Devon and some of the hilly areas of Ireland. In wet areas rushes appear.

### Limestone or basic grasslands

The springy turf that is characteristic of the chalk downs is almost proverbial. It is commonly referred to as downland. Similar grassland is found on other limestones in this country notably on the Jurassic limestones of the Cotswolds and a somewhat similar plant association reappears on some basic igneous rocks. The grasses of the siliceous grasslands are absent, and the bracken, the gorse and the rushes are on the whole uncommon. The heaths, too, are practically unknown. No one who is familiar with the delightful chalk downlands in the south of England will need to be reminded of the characteristic herbaceous flora, with numerous flowering herbs peculiar to itself, including many of our orchids. Generally the dominant grass is the red fescue (*Festuca rubra*) or sheep's fescue (*F. ovina*). Although a great proportion of the chalk pastures in England are old, it is going too far to say that the area has never been occupied by woodland. The chalk and limestone grasslands have, of course, long been famous as sheep pastures. Rabbits also were very abundant, and where they did occur in numbers the turf was even more closely nibbled than by the sheep. The fescue, with its wiry herbage, is very largely responsible for the springy nature of the turf, which is thus so delightful for walking. Myxomatosis almost wiped out the rabbit population in 1954.

### Arctic-Alpine grasslands and mountain vegetation

Arctic-Alpine grassland is practically restricted to the higher levels in the Highlands of Scotland. The grasses and other plants tend to have a rosette habit, and naturally the species occurring are of particular interest in view of what has been said above as to the possible origin of this vegetation. This, with certain very wet types of grassland, may be the only type of truly *natural* grassland in Britain.

## Fenland and freshwater marshland

The vegetation of fens, freshwater marshes, mosses and bogs is ecologically very interesting but economically unimportant. Some very reedy pastures

are intermediate in character and can be used for rough grazing, but the true fen and freshwater marsh are of little use except for the yield of rushes for such purposes as thatching.

## Salt marsh

The vegetation of regions which are characterised by the presence of salt in the soil or which are periodically flooded by salt water, whether regularly by the tide or only occasionally, consists of plants specially adapted to withstand these curious conditions, and known as halophytes. They are commonly fleshy plants of which the glassworts (*Salicornia*) are particularly characteristic. Some of the drier types of salt marsh can be used for occasional pasture. The numerous types of salt marsh are of particular interest to the ecologist, but are rather outside the scope of the present work. Those plants which bind and hold marine muds and enable land to be reclaimed are clearly of economic importance. Of these *Spartina townsendii* has colonised large areas in the south of England.

## Sea coast and sand-dune vegetation

Hard, wiry grasses are characteristic of the vegetation of young sand-dunes. Some of them are particularly valuable because of their ability to bind sand-dunes and prevent their movement over valuable land. The sea couch grass (*Agropyrum junceum*) and the marram or star grass (*Ammophila arundinacea*) are specially interesting in this connection. Occasionally a few goats find pasturage on sand-dune grasses, and there is quite a considerable use of older dunes as golf courses. The study of grasses suitable for planting as greens for the golf courses is thus a matter of some general interest.

It might be thought that the study of the natural and seminatural vegetation of the British Isles has comparatively little practical importance. This is very far from being the case. The natural vegetation of an area forms a perfect index of the sum total of conditions, particularly of soil and climate, which affect the growth of any plants which may be introduced by man. For example, in introducing foreign species of trees for afforestation experiments in Britain it may be essential that they should be introduced in regions where the environment corresponds with the environment where they are found to flourish in their own home localities. The character of such environment in this country can be gauged by the natural vegetation ordinarily existing though some exotic species when introduced are found to require conditions here different from those of their homeland. Further, a detailed study of the natural vegetation existing, for example, in our moorland tracts, is an indication as to what is wrong with the soil from the point of view of its further utilisation in other directions, e.g. in agriculture. The presence of rushes in ordinary meadows is definitely indicative of wet conditions. The occurrence of heath is clearly indicative of an entirely

different set of conditions. It is to be feared that some of the expensive early experiments in afforestation were carried out without a sufficient study of the local natural vegetation.


FIG. 77. National parks, forest parks, long distance paths and new towns, 1969

## National Parks and nature conservation

The increasing pressure of population on land resources has led in Britain to a comprehensive system of town and country planning, based mainly on an Act passed in 1947. An attempt is made to balance the needs of land for industry, housing, recreation, communication, service use and other 'urban' needs against agriculture and forestry. Arising out of the need to provide large areas of natural beauty primarily for recreation has come

the demarcation of National Parks in England and Wales—the Lake District, Northumberland, Peak District, Yorkshire Dales, North York Moors, Snowdonia, Dartmoor, Exmoor, Brecon Beacons and the Pembrokeshire Coast. These are under the general supervision of the National Parks Commission. Other areas are protected by being named 'Areas of Outstanding Natural Beauty' (AONB). There has also arisen a particular need to conserve areas where our native flora and fauna can continue to exist and be scientifically studied. The Nature Conservancy was established in 1949 and has general charge of this task, including the establishment and maintenance of nature reserves. The Reserves are usually small—the 72 demarcated in the first ten years totalled 57 000 hectares (140 000 acres)—and in contrast to National Parks it is often necessary to *limit* public access. The Conservancy has also notified a large number of Sites of Special Scientific Interest (SSSI) and as far as possible these are protected from building and other forms of development.

# 8
# Forestry and afforestation

Enough has been said in the chapter on Natural Vegetation to indicate that the climate of the whole of the British Isles is one favourable to the growth of forests, and that one must regard forests as the natural vegetation cover of the major part of the islands at least below 300 metres (1000 ft). As we travel about much of Britain, particularly the lowland counties of England, the southern part of Scotland, the valleys amongst the Highlands, as well as the valleys of Wales, we are, perhaps, impressed by the well-wooded nature of the country. But the impression is in reality an illusion, for under eight per cent of the surface of the United Kingdom is at the present day covered with forest and woodland (see p. 149). The lowlands of Britain are, of course, preeminently characterised by numerous small fields, usually separated by hedges, and almost inevitably one sees along these hedges isolated trees which have been allowed to grow up or perhaps were planted at the time of the Enclosures. Viewed from a distance, the isolated trees of the hedgerows and the scattered trees of our numerous parks give an impression of a well-timbered country which is in reality entirely false.[1] Yet in the past forests have played an important part in the economic life of Britain. In the early days the clearing of heavily forested land, particularly the damp oakwoods of the lowlands, presented a task beyond the capability of the early inhabitants of these islands. In the Middle Ages the products of our forests and woodlands played an essential part in the economic development of the country. To quote from an article written some years ago:[2] 'The three great uses of wood in the preindustrial period may be broadly said to be for construction, for domestic fuel and for industrial fuel. In the days when timber occupied a place in domestic architecture even more fundamentally important than it does today, when timber was the only material for the construction of ships and when timber rubbed against timber in the moving parts of the coach or the mill wheel, it was strength and durability which counted rather than ease of working. Consequently the old oak beams

1. It should be noted, however, that in many parts of Britain, particularly the arable areas, hedges are being grubbed up in the interests of mechanised farming, whilst the regeneration of hedgerow trees is prevented by the use of mechanical hedge-cutters in place of the skilled hedge-layer of the past.

2. L. D. Stamp, 'The forests of Europe, present and future', *Empire Forestry Journal*, 7, 1928, 85–102.

of the manor house, the massive timbers of the *Victory*, or the elaborately carved panels of a Jacobean press are symbolical standards of value which were the essential standards of the Middle Ages. The emphasis is obviously on the hard woods rather than on the softwoods. The association of the latter is rather with the blazing pine logs of the baronial hearth—the second great use of wood in the Middle Ages. Characteristic of the third great use is the now defunct iron industry of the Weald. The presence of large quantities of wood suitable for the manufacture of charcoal was the first consideration in determining the location of numerous industries, of which the smelting of iron was one.'

The Industrial Revolution was followed by the development of coal (including gas and electricity derived therefrom), and later of oil, as the principal domestic and industrial fuels and the rise to first rank of iron and steel as constructional materials. It would almost seem as if timber had become a superfluous commodity. Entirely supplanted by iron and steel in the construction of ships and machinery, very largely replaced in countries such as England as a domestic fuel and entirely as an industrial fuel, timber seemed to have been relegated to a position of minor importance in the economic life of the world.

The history of forestry in the nineteenth century reflects the unconscious reaction of these changes on the public mind. By that time British forests had almost gone: in the new lands of the world people of British stock were failing to appreciate forest wealth. The reckless depletion of forests by unregulated felling; the 'clearing' of enormous areas for agriculture by the incredibly barbarous method of burning off virgin forest; the lack of precautions against fire, and a dozen other things too familiar to necessitate enumeration, all indicate the low ebb of public appreciation of forest wealth.

But the present era is by no means an era which can do without forest products. There are innumerable uses now absorbing huge quantities of timber, such as the manufacture of wood pulp, chipboard and paper, as well as the constant demand for the time-honoured purposes of domestic architecture and the construction of furniture, and the now decreasing requirements of the railways for sleepers and the coal mines for pitprops.

The peculiar and serious position of Britain may be judged in several ways. In the first place there is the remarkable contrast with the remainder of Europe. Europe as a whole has roughly 30 per cent of its surface covered with forest, an average of about 0.32 hectares (0.8 acres) of forest for every inhabitant. Compared with the other countries of Europe, the United Kingdom is in the anomalous position of having the smallest proportion of forest area, as well as the smallest area per capita, of any major country. The useful forest and woodland covering the surface is only about 8 per cent of the whole and is equivalent to only about one-tenth of an acre per inhabitant. Europe, excluding the British Isles, is roughly self-supporting in the matter of timber, but there is certainly not sufficient surplus to supply

the huge requirements of this country. Forest resources have been so depleted in most of the European countries that it is with the utmost difficulty that an export of timber is maintained from such countries as Finland, Sweden, Poland, Norway, Czechoslovakia, Austria and Romania. There remains, of course, the greatest potential exporter, Russia. All the time there exists in the background the fact that Britain herself could supply, and should supply, a much greater proportion of her requirements than the 10 per cent which was characteristic of the 1960s. Despite recent progress, there are still vast areas of heathland and moorland and mountain side of little value which are capable of growing excellent timber or at least wood of economic value.

The attention of the Government was focused on the timber resources of the British Isles during the First World War. Shipping which was urgently required for the transport of food and troops had to be utilised for the importation of that very bulky commodity—timber. There was ammunition to be made, for which factories were required; they needed fuel and that fuel was provided by the coal mines. Coal could not be mined without the extensive use of pitprops. As early as 1916 the Reconstruction Committee set up a Forestry Sub-committee to consider ways and means whereby, in the event of another national emergency, an adequate supply of home-grown timber could be assured. The Sub-committee set before it the ideal that the British Isles should be self-supporting as regards timber throughout a period of at least three years. Among the recommendations of the Committee was that a Forestry Commission should be set up, and this Commission was actually appointed in 1919. The Forestry Commissioners calculated that it would be necessary to afforest 719 000 hectares (1 777 000 acres) in order to cover a national emergency lasting three years. Their scheme provided for the planting of this large area in the course of eighty years, two-thirds of the programme to be completed within the first forty years. In addition, the existing woodlands were to be rescued from the state of neglect into which they had long since drifted.

One of the first tasks undertaken by the Forestry Commissioners was a census of woodlands of Great Britain and a census of production of home-grown timber. Most of the information gathered related to the year 1924. The results showed that there were approximately 0.8 million hectares (1.9 million acres) of woodland of all types, including scrub and devastated forest, in England and Wales and 0.4 million hectares (1 million acres) in Scotland. The exact total for the whole of Great Britain was 1 198 212 hectares (2 958 673 acres) or 5.3 per cent of the land surface.

A similar census of woodlands was carried out in 1947 49 and the results published in 1952. By that time the total had reached 1 472 321 hectares (3 635 362 acres) (including an estimated 75 735 hectares (187 000 acres) for areas under 5 acres not actually measured) or 6.5 per cent of the land surface. The effects of the work of the Forestry Commission are at once apparent.

A further census was taken in 1965–67 and the results published in 1970. This revealed that the area of woodlands had still further expanded, as a result of a revived interest in commercial forestry as well as through the activities of the Commission, to 1.7 million hectares (4.3 million acres) or 7.6 per cent of the land surface. The two following tables summarise the data of these last two censuses.

*Distribution of woodlands by types and sub-types, 1947*

| TYPE | ENGLAND ACRES | % | WALES ACRES | % | SCOTLAND ACRES | % | GREAT BRITAIN ACRES | % |
|---|---|---|---|---|---|---|---|---|
| High forest: | | | | | | | | |
| Conifers | 331 275 | 18 | 97 438 | 31 | 439 084 | 34 | 867 797 | 25 |
| Mixed | 117 996 | 6 | 10 835 | 3 | 37 235 | 3 | 166 066 | 5 |
| Hardwoods | 580 286 | 31 | 77 633 | 25 | 97 017 | 8 | 754 936 | 22 |
| *Total high forest* | *1 029 557* | *55* | *185 906* | *59* | *573 336* | *45* | *1 788 799* | *52* |
| Coppice with standards | 227 423 | 12 | 2 276 | 1 | 89 | | 229 788 | 7 |
| Coppice | 102 637 | 6 | 17 082 | 5 | 487 | | 120 206 | 3 |
| Scrub | 200 040 | 10 | 40 228 | 13 | 256 683 | 20 | 496 951 | 15 |
| Devastated | 105 415 | 6 | 12 013 | 4 | 33 636 | 3 | 151 064 | 4 |
| Felled | | | | | | | | |
| before Sept. 1939 | 33 492 | 2 | 21 578 | 7 | 233 433 | 18 | 288 503 | 8 |
| since Sept 1939 | 166 482 | 9 | 37 395 | 11 | 169 174 | 14 | 373 051 | 11 |
| *Total felled* | *199 874* | *11* | *58 973* | *18* | *402 607* | *32* | *661 554* | *19* |
| Total | 1 865 046 | 100 | 316 478 | 100 | 1 266 838 | 100 | 3 448 362 | 100 |

*Distribution of woodlands by types and sub-types, 1965*

| FOREST TYPE | ENGLAND TH HA | TH. ACRES | % | WALES TH. HA | TH. ACRES | % | SCOTLAND TH. HA | TH. ACRES | % | GREAT BRITAIN TH HA | TH. ACRES | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| High forest. | | | | | | | | | | | | |
| Coniferous | 332 | 822 | 38 | 131 | 323 | 65 | 453 | 1121 | 69 | 917 | 2267 | 53 |
| Broadleaved | 285 | 705 | 32 | 25 | 63 | 13 | 39 | 97 | 6 | 350 | 864 | 20 |
| *Total high forest* | *617* | *1527* | *70* | *156* | *386* | *78* | *492* | *1218* | *75* | *1267* | *3131* | *73* |
| Coppice | 29 | 73 | 3 | | | | | | | 29 | 73 | 2 |
| Scrub and felled | 238 | 590 | 27 | 44 | 110 | 22 | 163 | 402 | 25 | 446 | 1101 | 25 |
| Total | 884 | 2189 | 100 | 200 | 496 | 100 | 655 | 1620 | 100 | 1742 | 4305 | 100 |

Figure 78 shows the approximate distribution of woodlands in Great Britain in 1947, and it will be noticed that the most heavily wooded portion of England was that immediately south of London, including the counties of Sussex (with as much as 15.5 per cent), Surrey (15.0), Kent (10.5) and Hampshire (14.9). In Scotland the most densely wooded part was the Buchan plateau between the Moray Firth and the Firth of Tay, including the counties of Nairn (with 19.1 per cent), Moray (21.6), Banff (10.0) and

Aberdeen (11.6). Farther south, Kincardine had 13.4 per cent. In the north and west the proportion dropped in Scotland to 0.4 in Caithness. All other Scottish counties had more than 2 per cent, but the western isles, considered separately, only 0.8 per cent.

Details were collected at both the 1924 and 1947 censuses as to the age of the trees in the forests, and a summary of these, together with somewhat similar data for 1965, is given in the following table.

*Age of woodlands (high forest)*

| AGE (YEARS) | PERCENTAGE OF TOTAL AREA | | | | | |
|---|---|---|---|---|---|---|
| | | | 1965 | | | |
| | 1924 | 1947 | TOTAL | CONI-FEROUS | BROAD-LEAVED | AGE (YEARS) |
| 1–10 | 8.5 | 14 | 42 | 58 | 10 | 1–15 |
| 11–20 | 9 | 16 | 10 | 13 | 5 | 15–25 |
| 21–40 | 18 | 15 | 18 | 21 | 8 | 25–45 |
| 41–80 | 39.5 | 15 | 7 | 4 | 13 | 45–65 |
| Over 80 | 25 | 14 | 21 | 4 | 64 | Over 65 |

These figures show very clearly three things; first, that stands of useful timber (over 20 years and especially over 40 years) were much depleted during the Second World War; secondly, the enormous amount of planting, and particularly of coniferous species, that has been done since the war, and thirdly, the fact that almost all the really mature forest is of broad-leaved species. It must be understood that forest grown for timber has a definite rotation over a number of years. Thus a coniferous forest in Britain was reckoned to be fit for cutting over for timber about every 80 years, that is to say it has an 80-year rotation. Hardwoods, on the other hand, based especially on the oak, have a longer rotation, and forests can only be cut over for large timber every 150 years. Mixed forests are calculated on a 120-year rotation.[1]

Coppice, and coppice with standards, represented nearly 18 per cent of the total area of woodlands in 1924, but only 10 per cent in 1947. Most of this area was to be found in southern England; indeed almost half the woods of this description were in the four counties of the southeast—Kent, Surrey, Sussex and Hampshire—where the coppice with standards was very largely the remnant of the former covering of damp oakwoods on the heavier soils in this part of England. The produce from these woods—mainly chestnut and hazel—was largely hop poles—which are no longer in demand owing

1. These are approximate figures used in the earlier census reports. Actually, various rotations are employed when woodland is regularly managed, and Forestry Commission calculations of yield are now based on a rotation of between 55 and 70 years for all conifers except Scots pine; the reduction results from improved techniques of planting, thinning and general forest management.

to the substitution of semipermanent wiring—and fence poles—now replaced by concrete or metal posts. It is thus not surprising that in 1965 the areas worked as coppice represented only 3 per cent of the total English woodlands, with almost none in Wales and none at all in Scotland. Those coppiced woodlands no longer worked as coppice were reclassified in the 1965 census as high forest or as scrub, according to their condition.

The large area of scrub and felled woodland—446 000 hectares (over a million acres) in 1965, or 25 per cent of the total woodland area—represents

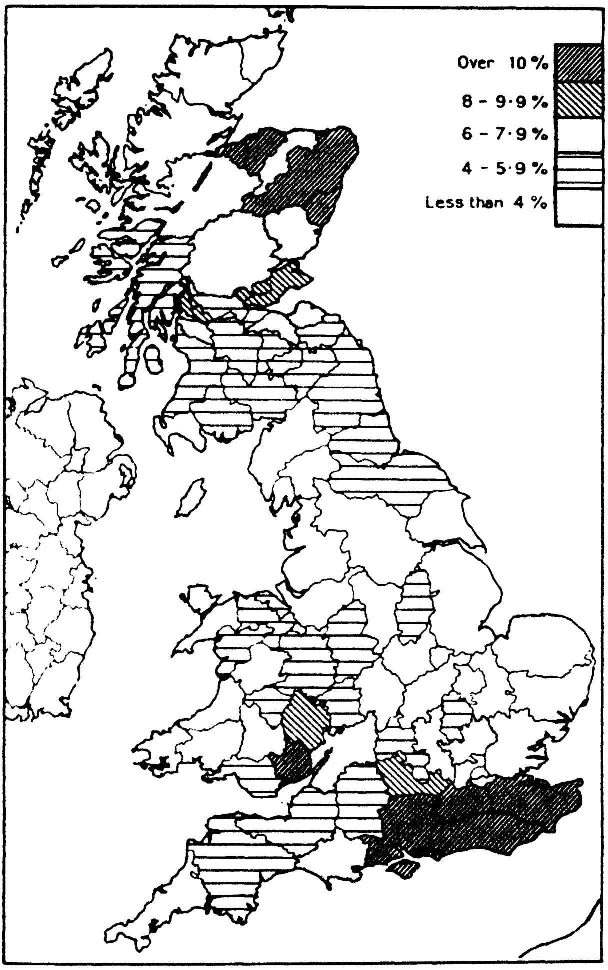



FIG. 78. The wooded areas of Great Britain, according to the census of woodlands of 1947, showing the proportion of the surface of each county occupied by forest and woodland. In 1965 the following counties were also included in the 'over 10%' class: Northumberland, Perth, Glamorgan, Brecon and Montgomery (the last two shown as 'under 4%' in 1947)

PLATE 1. Beechwood at Slindon, Sussex. Very sparse ground flora

a possible reserve of afforestable land. About 15 per cent of it could be called low-grade high forest, capable of yielding some timber, but the remaining 85 per cent, mostly in private ownership, is unutilisable, though much of it could undoubtedly be replanted with high forest crops. There are considerable areas in the Scottish Highlands, particularly in Argyll and Inverness, consisting of sparse stands of birch. In the west of Wales a poor cover of dwarf oak is common and similar tracts in parts of Dartmoor are believed to be true primeval forest remnants. In addition there are overgrown coppices, and woods devastated during the Second World War and not replanted.

Since the Second World War afforestation has become more and more a matter for the State. With the heavy incidence of death duties and the consequent breaking up of large landed estates, there has been little if any incentive for private owners to plant trees which cannot mature in the lifetime of the planter. In 1924, 96 per cent, and in 1947, 82 per cent of the woodland area in Great Britain was in private ownership but by 1965 this had been reduced to 62 per cent—74 per cent in England, 54 per cent in Scotland and 42 per cent in Wales. There is a very important contrast between these private woodlands and those of the Forestry Commission, for of the 1 087 500 hectares (2 687 000 acres) of private woodlands, 298 700 hectares (738 000 acres) or 27 per cent consisted of broadleaved high forest, and this represented 85 per cent of all the broadleaved high forest in Great Britain. On the other hand, only 37 per cent of the coniferous high forest is in private hands, the remaining 63 per cent being owned by the Forestry Commission.

The Forestry Commission's policy of planting mainly coniferous species (in response to the known economic demand) proved unpopular with the general public in the early years. Britain is a land of deciduous trees and has only three native conifers—the Scots pine (*Pinus sylvestris*) which is the only timber tree, the juniper and the yew—and a considerable section of the public, having grown accustomed to the open, windswept moorlands and mountains, disliked the regimented plantations of introduced conifers, arranged in straight-sided blocks and all of one age. The amenity objections are still sometimes raised—but at least the forests do not normally take up agricultural land (apart from moorland sheep-runs) and with the increasing maturity of the forests and a policy of limited public access the Commission's work is now more generally appreciated, particularly in the areas where it has provided employment and homes. In addition to its own forests the Commission now supervises private woodlands 'dedicated' for the purpose.

At the census of 1965, 28 per cent of the high forest was of broadleaved species and 72 per cent coniferous. Within the broadleaved category, oak forests represented 13 per cent of all the high forest area (but 23 per cent of that in England). The chief stands were to be found in southeast England and the Forest of Dean, and the only major areas outside the southern half

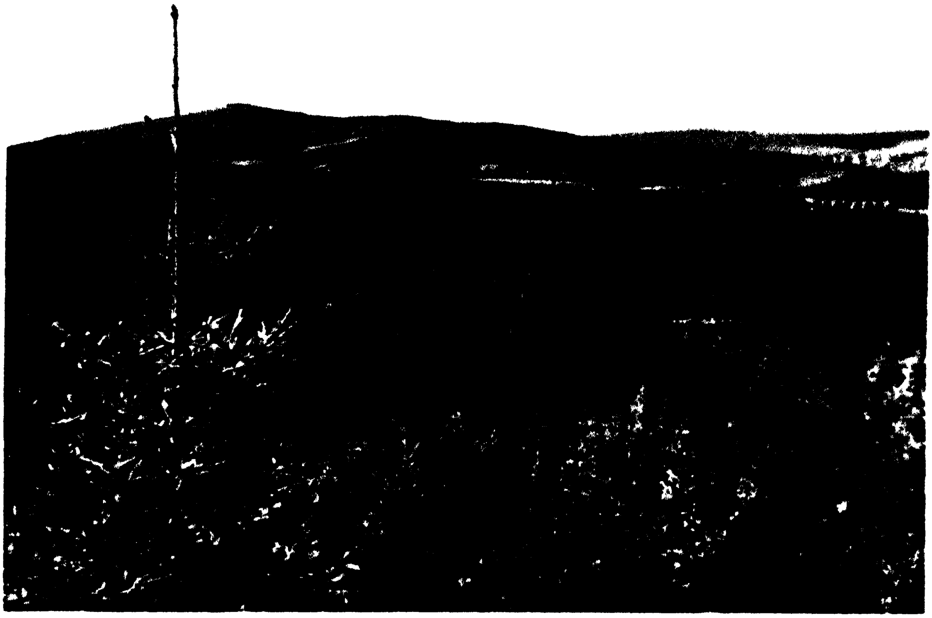


PLATE 2. Sprucewoods in Kielder Forest, Northumberland

of England and Wales were in the valleys on the southern fringe of the Lake District. Beech (*Fagus sylvatica*) occupied 5 per cent of the high forest area mostly on the chalk and limestone of the Chilterns and Cotswolds, and in the New Forest of Hampshire. Other important broadleaved species included ash (*Fraxinus excelsior*), birch (*Betula verrucosa*), sycamore (*Acer pseudoplatanus*) and elm (*Ulmus* spp).

Conifers in 1965 were headed by Scots pine with 20 per cent of the high forest area. Pines—natural and planted—are to be found in the sandy-soiled lowland areas of England such as the New Forest, Thetford Chase, the Bagshot area, Cannock Chase and Sherwood Forest, and in northern Scotland on the lowlands around the Moray Firth. The pine produces excellent pitprops as well as timber for other purposes. In recent years however, largely in response to the increasing demand for wood pulp and chipwood for paper and board manufacture, the spruce, especially Sitka spruce (*Picea sitchensis*) and Norway spruce (*P. abies*) has been very widely planted, especially in the Border forests, in western Scotland and in Wales. In 1965 Sitka spruce represented 20 per cent of all the high forest area (but 28 per cent in Scotland and 37 per cent in Wales), and in 1967 out of 86 million new trees planted by the Forestry Commission, no less than 41 million were Sitka spruce, mostly in Scotland and north Wales. In these high rainfall regions the spruce is capable of producing up to three times

as much timber per acre as the pines. Other conifers include the lodgepole pine (*Pinus contorta*) of which 17 million were planted in 1967, the Corsican pine (*P. laricio*), the Japanese and European larches (*Larix kaempferi* and *L. europaea*) and the Douglas fir (*Pseudotsuga menziesii*).

The State Forests of the Forestry Commission are widely distributed (Fig. 79). The largest is Kielder in Northumberland, with nearly 20 000 hectares (48 000 acres) planted; others in the Border country—including Wark and Redesdale—bring the total for this area up to 48 500 hectares (120 000 acres). Thetford Chase, on the former Breckland of Norfolk and Suffolk, has 19 000 hectares (47 000 acres), whilst the former Crown Woodlands of the New Forest and Forest of Dean have 11 700 hectares (29 000 acres) and 8 500 hectares (21 000 acres) respectively. Allerston forest in northeast Yorkshire has 11 300 hectares (28 000 acres) planted, and Hambleton forest, also in Yorkshire, has 5 600 hectares (14 000 acres); whilst Sherwood forest in Nottinghamshire covers nearly 5 600 hectares (14 000 acres). In Wales the largest forests are Coed Morgannwg in Glamorgan with 13 700 hectares (34 000 acres) and three forests in Merioneth and neighbouring counties which together cover 20 000 hectares (48 000 acres). The largest in Scotland are Glen Trool 9 700 hectares (24 000 acres) and the Forest of Ae 5 200 hectares (13 000 acres) in the southwest, Clashindarrock 5 200 hectares (13 000 acres) and Speymouth 4 800 hectares

PLATE 3. Pitprops from thinnings in Monaughty forest, Morayshire

(12 000 acres) in the northeast, Black Isle in Ross-shire 5 600 hectares (14 000 acres) in the north, and Loch Ard 6 500 hectares (16 000 acres) in the central Highlands. Only a few others cover more than 4 000 hectares (10 000 acres), but the total area was 817 300 hectares (2 019 500 acres) at 31 March 1969. At this date the Forestry Commission employed about

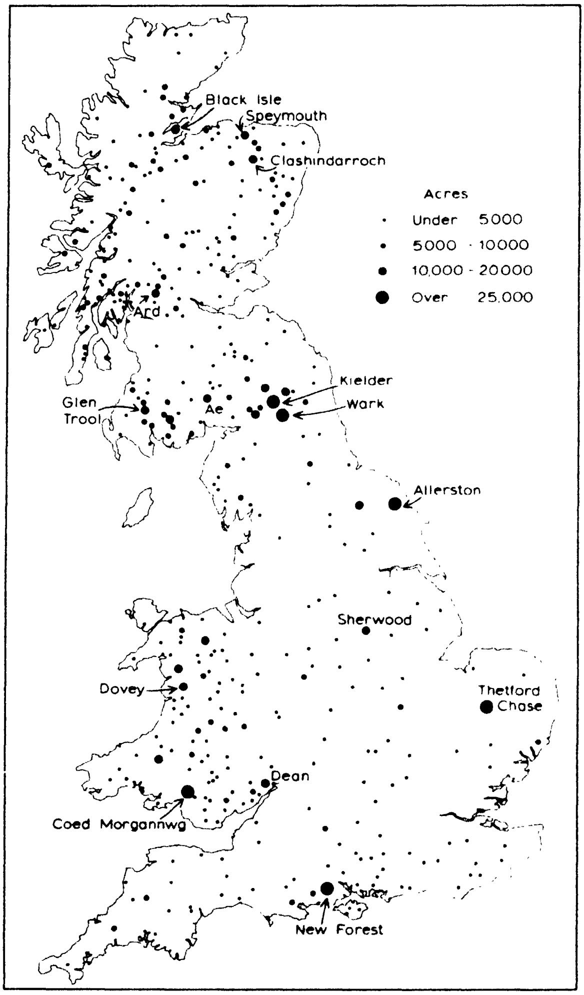



FIG. 79. Forestry Commission plantations

10 000 people out of a United Kingdom total in forestry of about 22 000.

Afforestation can undoubtedly bring about an amelioration of conditions for human life in many parts of the country. A good example is afforded by the western Highlands of Scotland.[1] Over most of this area

1. See J. Claxton, 'Afforestation in the Western Highlands and its effect on repopulation', *Geography*, 17, 1932, 193–203.

there has long been a steady rural depopulation, commencing with the disruption of the Clan system after the 1745 rebellion and carried on through later years when the crofting population of the valleys was replaced by a small number of shepherds; and then later an equally small, or smaller, number of gamekeepers and stalkers replaced the shepherds. The large acreage of deer forest has already been noted. In 1883 it was less than 0.8 million hectares (2 million acres), but by 1930 it had increased to approximately 1.4 million hectares (3.5 million acres); and it must be admitted that this does not represent the highest utilisation of the land. Many of these rough grazings and deer forests have since 1930 been or are being acquired by the Forestry Commissioners. The permanent forest employees have a cottage and some cultivable land, giving them a definite interest in the countryside quite apart from their work in the forests; and each worker's holding means the establishment not of one person only but of a family of four or five. The work in forest areas does not, of course, end with the planting operations, more especially when one remembers that it is not the intention to plant the units purchased for afforestation all at one time, but rather to spread the work over ten to thirty years. In this case by the time the forest unit has been fully planted it is time to begin thinning —the cutting down of certain trees to provide increased room for selected ones. On this basis it is estimated that every 40 hectares (about 100 acres) of forest will supply permanent employment for one man and his family until the first clear fellings are made when the trees are sixty or eighty years old. Actually, because of the large amount of afforestation work undertaken, the northwest Highlands of Scotland have shown that it requires about one man for every 20 hectares (50 acres). Nor does this represent the full total for there is obviously a demand for schools, for shops, for professional men, for transport workers supplying motor bus services, and so on, and a permanent rural population of some twenty per square kilometre (fifty per square mile) in afforested areas of the Highlands of Scotland is probably not a bad estimate.

## Uses of homegrown wood

Three major types of wood are produced. First, softwood small roundwood; this is mainly spruce, Scots pine, lodgepole pine, larch and other conifers, of a diameter between about 7.5 and 20 centimetres (3 and 8 in). In 1965, some 41 per cent of the output went into coal mines, 23 per cent for pulp manufacture and 19 per cent for fibreboard and wood chipboard; but the market is changing rapidly, and by 1980 the mines may well consume under 10 per cent whilst the pulp-mills take over 60 per cent.[1] At present the country supplies only 3 per cent of its pulpwood requirements (cf.

1. B. W. Holtam, 'Homegrown roundwood', *Forest Record*, 52, H.M.S.O. 1966.

p. 616), but 70 per cent of its pitwood (compared with under 10 per cent before the Second World War).

Secondly, softwood logs for the production of sawn planks, mainly for use in building: at present only 2.5 per cent of the country's requirements is home-produced, for our conifer forests are not yet mature enough and large imports from Canada, the Scandinavian countries and Russia are necessary. Thirdly, hardwood logs, of which the country produces 25 per cent of its requirements (the remainder comprising 25 per cent temperate hardwoods, mainly from European sources and 50 per cent tropical hardwoods). Most of the oak, beech and other broadleaved forests and woodlands old enough to produce merchantable timber are in private ownership, and mainly in the southern half of England and Wales.

Figure 80 shows the location of the principal wood-processing industries that are based wholly or in part upon homegrown wood. Most of these produce chipboard or fibre building boards; a few produce mechanical

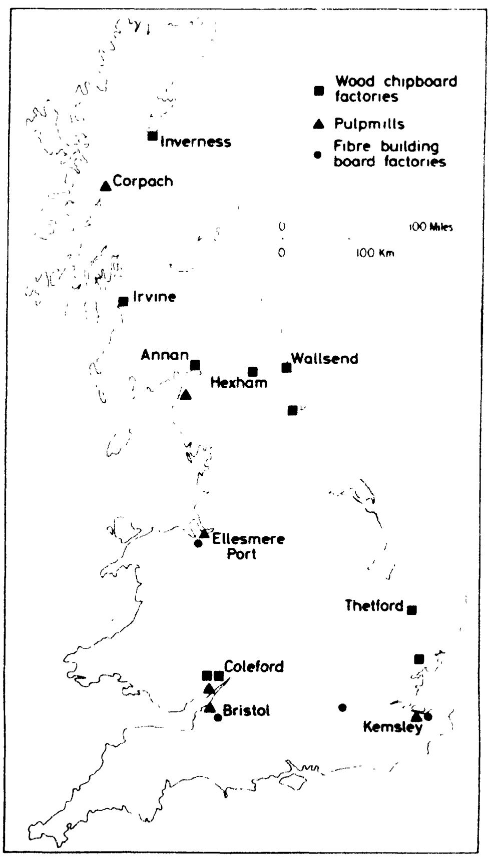



FIG. 80. Wood-processing industries based on home-grown timber

pulp from ground-up wood, for use in paper or cardboard manufacture, but the most interesting and novel is the chemical pulp mill, integrated with a paper mill and a sawmill, at Corpach, near Fort William, established in 1966. The logs for this mill are brought by lorry, by rail or by water from coniferous forests within a radius of some eighty kilometres (fifty miles), and cargoes of wood chips arrive from Canada. Some 700 people are employed in the mill—an obvious advantage to a Highland area that is suffering from a severe lack of employment opportunities; but the economic margin is a delicate one, for the mill must compete with north American and Scandinavian plants that depend on wood that is derived from forests that are natural and not created by the expenditure of heavy capital resources as in Scotland.

## Northern Ireland[1]

The position in Northern Ireland is somewhat different from that in Great Britain. In early historical times Ireland was a land of bogs and forests inhabited by small clans who lived by herding, hunting and raiding rather than agriculture. Over the whole the clearing of the woodland came later than in Britain, but was eventually far more complete. That small area around Dublin known as the English Pale where direct English rule was established by the Normans was cleared of forest for military reasons and the clearance was extended to the Central Main so that by Elizabeth's reign it was reported nearly destitute of trees. It was not however till 1608 that the power of the last native chieftain in the northern province was broken and in 1609 began the systematic settlement of Ulster with English and Scottish colonists—the so-called Plantation of Ulster. The settlers cleared the woods to make room for agriculture and the process was continued by the Stuarts and the Cromwellian settlement of 1652; there was also a reckless exploitation for fuel, for the ironworks and for export, so that by 1698 the first of several abortive Acts was passed requiring the planting of trees.

Although the Royal Dublin Society from its foundation in 1831 did much to encourage planting, as did landowners individually, Northern Ireland remained a comparatively treeless country. When the Government of Northern Ireland was established in 1921, it became the forest authority. At that time less than 1.5 per cent of the land area was classed as forest and woodland. By following a policy comparable with that of the Forestry Commission the area has crept up gradually. An average of 400 hectares (a thousand acres) a year were planted from 1928 to 1948 and lately five times that rate. In 1962 the total forest area of Northern Ireland was recorded as about 283 000 hectares (700 000 acres) or roughly 3 per cent of the land area.

1. J. Pimlott, 'The history of afforestation in Northern Ireland', *Advmt Sci.*, **9**, 1952, 297–303.

# 9
# Land use in the British Isles

In England and Wales the Ministry of Agriculture, Fisheries and Food is responsible for collecting and publishing in outline statistics showing the principal uses of the land of the country. In Scotland the same function is performed by the Department of Agriculture for Scotland; in Northern Ireland by the Ministry of Agriculture; and in the Irish Republic by the Department of Agriculture. In England and Wales every year 'the Minister of Agriculture, Fisheries and Food requires a return in writing to be made' by each owner or occupier of agricultural land exceeding 0.4 hectare (1 acre), specifying the acreage of the several crops and of land in fallow or used for grazing, the number of livestock on the land and the number of persons employed thereon on 4 June. Similar returns are made in Scotland, Northern Ireland and in the Irish Republic. The returns so made are strictly confidential, but the acreages given are added together for each parish, and parish figures may be obtained on payment from the Ministry concerned. The published statistics refer to administrative counties. In addition the Forestry Commission collects statistics of forest, woodland and plantations in England, Wales and Scotland, so that the acreages of these are available from time to time.

Combining the statistics available and expressing the figures in percentages of the whole areas the following tables show in comparative form the use which was made of the land of the British Isles in the depression year 1933 and for the year 1950 when the country was still faced with the need of maintaining food production from agricultural land, together with the position in 1960.

The tables demonstrate certain salient points. In the first place there is the extremely small area actually covered by woods, forests and plantations in all parts of the British Isles. Forest and woodland actually occupy a smaller proportion of the surface in the British Isles than in any other important European country. This is notwithstanding the fact that the natural vegetation of the greater part of the British Isles is forest, and two thousand years ago forest must have covered the greater part of the country at least below 300 metres (1000 ft). Further, it is curious because, to the casual observer, the British Isles still appear to be well wooded. This, of course, is very largely due to the numerous small woods, shaws, and hedgerows with isolated trees, as well as the large proportion of parkland which

is so characteristic of the country, especially in the southeast. It must be admitted that the position until recently was little short of a scandal when one has a country which is essentially one which could be forest-covered and which has incredibly large tracts of moorland or heathland which might well be productive of good timber.

*Land use, 1933 and 1950 (in brackets)*

| | WOODS AND PLANTATIONS PER CENT | | ROUGH GRAZING LAND PER CENT | | PERMANENT PASTURE PER CENT | | ARABLE PER CENT | | OTHER LAND PER CENT | |
|---|---|---|---|---|---|---|---|---|---|---|
| England | 5.1 | (5.8) | 11.3 | (8.0) | 42.8 | (28.2) | 26.5 | (40.0) | 14.3 | (18.0) |
| Wales | 5.0 | (6.2) | 33.8 | (27.4) | 41.8 | (29.1) | 11.9 | (21.1) | 7.5 | (16.2) |
| Scotland | 5.6 | (6.6) | 66.8 | (57.3) | 8.3 | (6.2) | 15.9 | (16.8) | 3.4 | (13.1) |
| *Great Britain* | *5.6* | *(6.6)* | *28.2* | *(29.0)* | *31.4* | *(20.8)* | *21.8* | *(30.6)* | *13.0* | *(12.8)* |
| Northern Ireland | 1.3 | (1.7) | 15.7 | (21.2) | 45.6 | (32.6) | 27.9 | (36.0) | 9.5 | (8.5) |
| *United Kingdom* | *5.4* | *(6.4)* | *26.5* | *(28.7)* | *33.0* | *(21.4)* | *22.4* | *(30.8)* | *12.7* | *(11.7)* |
| Irish Republic | 1.4 | (1.7) | 12.0 | (10.0) | 47.3 | (44.7) | 21.4 | (23.3) | 17.9 | (20.3) |

*Land use, 1960*

| | WOODS AND PLANTATIONS | ROUGH GRAZING LAND | PERMANENT PASTURE | ARABLE | OTHER LAND |
|---|---|---|---|---|---|
| England | 6.5 | 10.3 | 28.1 | 39.9 | 15.2 |
| Wales | 8.9 | 32.8 | 34.2 | 16.1 | 8.0 |
| Scotland | 8.4 | 65.7 | 6.7 | 16.0 | 3.2 |
| *Great Britain* | *7.4* | *31.2* | *21.2* | *30.4* | *9.8* |
| Northern Ireland | 1.8 | 34.2 | 25.0 | 30.0 | 9.0 |
| *United Kingdom* | *7.0* | *31.3* | *21.5* | *30.4* | *9.8* |
| Irish Republic | 1.8 | ...[1] | 43.3 | 22.6 | 32.3 |

[1] Included in 'other land'.

The rough grazing land referred to in the second column is for the most part heathland and moorland occupying upland tracts. In England a considerable percentage represents land on the Pennines, the upland areas of the southwestern peninsula and the heaths of southeastern and central England. In Wales the much higher proportion reflects the large extent of moorland in the mountainous areas. It is scarcely surprising to find two-thirds of the surface of Scotland listed as rough grazing land in view of the large extent of the Highlands and of the Southern Uplands (Fig. 81). Lowland Ireland, with its improved pastures, has on the other hand comparatively little rough grazing. By adding together the figures for permanent pasture and arable land one gets the proportion of the country which may

be regarded as improved farming land—nearly two-thirds of the whole in the case of England, only a little over half in the case of Wales, only a quarter in Scotland, but approximately three-quarters in both the Irish Republic and Northern Ireland. Perhaps the most interesting column in this table is the last one, headed 'Other land', for which official details are not available. It is curious that until recently we had no statistics as to what exactly is the use made of a seventh of the surface of England.

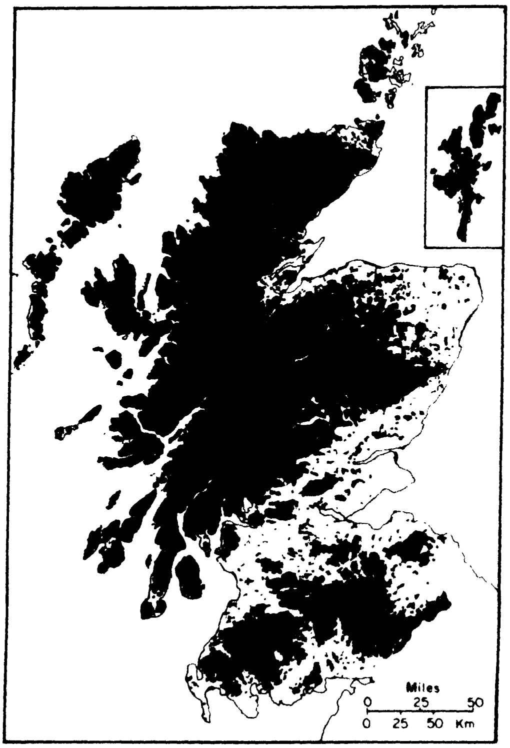



FIG. 81. The moorland (or rough grazing land, including deer 'forests') of Scotland

A comparison of the two tables opposite shows that in 1925 72.3 per cent of the surface of England and Wales and 74.2 per cent of Scotland was agricultural land of which particulars were furnished annually by owners or occupiers, whereas in 1960 the totals had been swollen by the inclusion of open grazing in common ownership. If one takes improved farm land only (crops and grass) the total in Great Britain (England, Wales and Scotland) had dropped from a total of 12 332 250 hectares (30 450 000 acres) in 1925 to 11 665 400 hectares (28 803 500 acres) in 1960. This is a loss of 666 800 hectares (1 646 500 acres) in thirty-five years or 19 000 hectares (47 000 acres) a year, despite some reclamation and is a measure of the

spread of industry, housing, mineral working, etc. Actually the loss is greater, as returns of agricultural land are more complete than formerly.

*Agricultural statistics of the British Isles, 1925*

| | | ENGLAND AND WALES | SCOTLAND | NORTHERN IRELAND | IRISH REPUBLIC |
|---|---|---|---|---|---|
| Area exclusive of inland water and tidal land | acres | 37 136 000 | 19 070 000 | 3 351 500 | 17 024 500 |
| | hectares | 15 040 000 | 7 723 300 | 1 357 300 | 6 894 900 |
| Arable | acres | 10 682 000 | 3 229 000 | 573 800 | 1 552 000 |
| | hectares | 4 326 200 | 1 307 700 | 232 300 | 628 600 |
| Permanent grass | acres | 15 073 000 | 1 476 000 | 1 217 200 | 10 704 000 |
| | hectares | 6 104 600 | 597 800 | 493 000 | 4 335 200 |
| Rough grazing (private) | acres | 1 104 000 | 9 250 000 | 514 500 | not recorded |
| | hectares | 447 100 | 3 746 200 | 208 400 | not recorded |
| Not accounted for in the annual agricultural returns | acres | 10 277 000 | 5 115 000 | 1 046 000 | 4 768 000 |
| | hectares | 4 162 100 | 2 071 600 | 423 600 | 1 931 100 |
| | | (27.7% of whole) | (26.8% of whole) | (31.2% of whole) | (28.0% of whole) |

Figures exclude the Isle of Man and Channel Isles.

*Agricultural statistics of the British Isles, 1960*

| | | ENGLAND AND WALES | SCOTLAND | NORTHERN IRELAND | IRISH REPUBLIC |
|---|---|---|---|---|---|
| Area (as above) | acres | 37 134 100 | 19 068 700 | 3 351 500 | 17 024 000 |
| | hectares | 15 039 300 | 7 722 800 | 1 357 300 | 6 894 700 |
| Arable | acres | 13 681 500 | 3 142 000 | 1 005 500 | 3 847 400 |
| | hectares | 5 541 000 | 1 272 500 | 407 200 | 1 558 200 |
| Permanent grass | acres | 10 792 400 | 1 187 600 | 838 000 | 7 385 600 |
| | hectares | 4 370 700 | 481 000 | 339 400 | 2 991 200 |
| Rough grazing | acres | 4 999 300 | 12 524 800 | 1 146 000 | not recorded |
| | hectares | 2 024 700 | 5 072 500 | 464 100 | not recorded |
| Not accounted for | acres | 7 660 900 | 2 214 300 | 362 000 | 5 791 000 |
| | hectares | 3 102 600 | 896 800 | 146 600 | 2 345 300 |
| | | (20.7%) | (11.6%) | (10.8%) | (34.1%) |

The total land area of the United Kingdom (England, Wales, Scotland and Northern Ireland) is 24 110 865 hectares (59 533 000 acres) or 240 925 square kilometres (93 021 square miles). On this area live 52 673 221 people according to the 1961 census. This means that the share per head of popu-

lation of land of *all types* is a little over 0.45 hectares (1⅛ acres) per head. The acreage per capita of improved farm land (crops and grass) at 12.3 million hectares (30.5 million acres) is under 0.24 hectares (0.6 acre). If England and Wales are considered apart from Scotland and Northern Ireland, it is only 0.32 hectare (0.8 acre) of land of all types or 0.21 hectare (0.53 acre) of improved farm land per head. Taking the world as a whole the land area represents about 4.8 hectares (12 acres) of land of all sorts per head of population of which about 0.5 hectare (rather over 1 acre) is productive farm land. The experience in the intensively cultivated countries of northwestern Europe suggests that, with present systems of farming it takes about 0.5 hectare (one acre) to produce the food for one person on an adequate northwest European standard. On this basis, Britain can or should produce 55 per cent of the food consumed or alternately can feed from home resources some 55 per cent of the population. Actually the 'target' of the postwar government in 1950–53 was about 55 per cent of the food consumed, leaving 45 per cent to be imported.

These figures illustrate the extreme pressure on land in Britain and the need for land use planning.

## The Land Utilisation Survey of Britain

Official statistics record acreage under certain types of land use, but do not permit the areas to be precisely located. Moreover, as the table on p. 151 shows, more than a quarter of the whole country was left unexplained.

It was in order to map the distribution of different types of land use and to supplement the statistics collected by the Ministry of Agriculture that the Land Utilisation Survey of Britain was formed in 1930, and carried out a survey of the country in the years 1931 to 1939. The aim of the Survey, an organisation whose work was carried out by volunteers all over the country, was to show what use was being made of every single field in the whole of Great Britain.[1] The field work was done on the maps published by the Ordnance Survey on the scale of 6 inches to the mile, since these show the individual fields. The classification adopted by the Survey was drawn up so as to correspond as closely as possible with that used in the official statistics.

1. *Forest and Woodland.* Woodland is marked on the one-inch maps and the six-inch maps published by the Ordnance Survey, and the character of the woodland is broadly indicated by symbols showing whether the trees are coniferous, deciduous or mixed, whilst other symbols indicate woodland of a scrubby nature. A classification of British woodland was drawn up by the Forestry Commissioners for the purpose of the Census of Woodlands taken in 1924, and this classification was adopted by the Land Utilisation Survey.

1. At a slightly later stage a similar survey was carried out in Northern Ireland under the direction of Mr D. A. Hill and the results published.

| *Description* | *Letter marking* | *Colour marking* |
|---|---|---|
| 1. Forest and woodland | F | Dark green |
| 2. Meadowland and permanent grass | M | Light green |
| 3. Arable or tilled land, fallow, rotation grass, and market gardens | A | Brown |
| 4. Heathland, moorland, commons, and rough hill pasture | H | Yellow |
| 5. Gardens, allotments, etc. | G | Purple |
| 6. Orchards | O | Purple ruling |
| 7. Nurseries | N | Purple hatching |
| 8. Land agriculturally unproductive, e.g. buildings, yards, mines, cemeteries, etc. | W | Red |
| 9. Ponds, lakes, reservoirs, ditches, dykes, streams, and anything containing water | P | Blue |

(*a*) *High forest* (Fa) of trees which are being grown primarily for timber or which can be used for that purpose. When fully grown the trees in the high forest are sufficiently close for their crowns to touch. High forest can be divided into forests of conifers ($Fa^c$) and hardwoods ($Fa^d$) and of mixed conifers and hardwoods ($Fa^m$). The hardwoods are, of course, the ordinary deciduous trees, but the deciduous larch is included as one of the conifers.
(*b*) *Coppice* (Fb), or coppice with standards, woodland that is cut over every ten or fifteen years for fencing, posts, etc. The number of large trees or standards left varies, but they are not sufficiently close for the woodland to be called high forest.
(*c*) *Scrub* (Fc) consisting of small bushes or trees unfit for the production of timber.
(*d*) *Derelict forest* (Fd) which has been cut or devastated.
2. *Meadowland or pasture and permanent grassland.* In the annual returns made by farmers or other occupiers of agricultural land a distinction is drawn between permanent grassland for mowing and permanent grassland used as pasture. Owing to changes in practice from year to year the distinction was not made by the Land Utilisation Survey, but the category of course excludes rotation grass—grass grown in rotation with crops.
3. *Arable, or tilled, land.* In any one year land normally ploughed may fall into one of three divisions: that used for clover or rotation grasses, that occupied by crops, and that lying fallow. The three are included together in the maps of the Land Utilisation Survey.
4. *Heathland, moorland and rough hill pasture.* This type of land is usually distinguished on the six-inch maps and in some cases on the one-inch maps. Swampy or reedy pastures and marshland which can be used as rough pasture have been included here by the Land Utilisation Survey. In the agricultural returns farmers make a return of this type of land, over which they have exclusive grazing rights, but only estimates are available of the

areas where grazing rights are communal and of areas of similar character which are not actually used for grazing purposes (see below, p. 156).

5. *Gardens, allotments, etc.* In the scheme drawn up by the Land Utilisation Survey houses with gardens sufficiently large to grow a few vegetables, or even flowers, are included in this category; but where there are only back yards or small areas which must be agriculturally unproductive, land used for housing falls into another category. Broadly the line is drawn where houses are fewer or more than 12 per acre. Allotments are to be regarded as gardens at a distance from the cultivator's house. Large private parks have been split up by the Land Utilisation Survey according to the actual use which is made of the land, much of it naturally being permanent pasture.

6–7. *Orchards* and *nurseries* have been separately shown on most of the published maps.

8. *Land agriculturally unproductive.* This category includes buildings, yards, railways, mines, cemeteries, as well as waste land, i.e. all ground of which the soil is not productively used. On the maps of the Land Utilisation Survey, the difference between land in this category covered with buildings and land which is purely waste is readily apparent—except in the case of recent developments—because of the presence or absence of symbols for buildings.

It will thus be seen that the work of the Land Utilisation Survey was to show for the years 1931–39 the exact use being made of every portion of the surface. The bulk of the work referred to the years 1931–33, only some of the remoter areas being covered at a later date and the whole was complete before the outbreak of war in September 1939. The Survey thus recorded the utilisation of land at a time which may well represent the *nadir* of British agriculture.

The material collected by the Survey was published in several ways. The coloured 1-inch maps (with usually the same sheet lines and the same base maps, including water and contours, as the Popular Series of the Ordnance Survey though sometimes combining two sheets) which were published totalled 168 sheets covering the more populous parts of Britain—the whole of England and the whole of Wales, and the South and Midland Valley of Scotland—as well as sample areas elsewhere. For the remainder of Scotland, the MSS coloured 1-inch maps can be consulted at the Royal Geographical Society in London. Finally, a generalised map on the scale of 1:625 000 or roughly 10 miles to 1 inch, in two sheets, covered the whole of Great Britain.

The details shown on the maps were analysed and the factors influencing present land use and its evolution were studied in detail in the series of county memoirs. This Report, under the title of *The Land of Britain*, was issued in 92 parts, one for each county, the whole forming nine quarto volumes (1937–46) to which a separate part covering the Channel Islands

was added later. The main results have been summarised in Stamp, *The Land of Britain: its use and misuse*, which should be consulted on matters relative to the use of Britain's land. In common with all the county reports, details are given of historical and economic aspects of land use and special attention is given to factors of permanent importance affecting town and country planning. When the present utilisation is compared with that in the past it is found that on the best and also on the poorest land there is considerable stability of land use (except where housing or industrial development has taken place) but on land of intermediate quality economic factors have completely altered the type of utilisation in the last hundred years.

*Summary table of the findings of the Land Utilisation Survey*

| | ENGLAND | | WALES | | ISLE OF MAN | | SCOTLAND | | GREAT BRITAIN | |
|---|---|---|---|---|---|---|---|---|---|---|
| | ACRES | % | ACRES | % | ACRES | % | ACRES | % | ACRES | % |
| Arable | 8 339 400 | 26.0 | 535 900 | 10.5 | 65 500 | 46.5 | 3 128 600 | 16.4 | 12 069 400 | 21.4 |
| Permanent grass | 15 239 400 | 47.7 | 2 167 800 | 42.5 | 19 900 | 14.2 | 1 470 400 | 7.7 | 18 897 500 | 33.5 |
| Orchards | 257 100 | 0.8 | 3 400 | 0.1 | — | — | 800 | — | 261 300 | 0.5 |
| Forest and wood | 1 827 900 | 5.7 | 294 200 | 5.8 | 2 800 | 2.0 | 1 094 300 | 5.8 | 3 219 200 | 5.7 |
| Rough grazing | 3 812 700 | 11.9 | 1 906 400 | 37.4 | 44 800 | 31.6 | 13 011 300 | 68.2 | 18 775 200 | 33.3 |
| Houses with gardens | 1 487 500 | 4.6 | 73 300 | 1.4 | 3 800 | 2.7 | 155 300 | 0.8 | 1 719 900 | 3.1 |
| Agriculturally unproductive | 1 069 600 | 3.3 | 117 700 | 2.3 | 4 200 | 3.0 | 207 700 | 1.1 | 1 399 200 | 2.5 |
| Total | 32 033 600 | | 5 098 700 | | 141 000 | | 19 068 400 | | 56 341 700 | |

This table refers to conditions as they were before the plough-up campaign of the Second World War. (1000 acres = 404.7 hectares)

It is also clear, when viewed over the past century and a half, that the natural or geographical factors are of increasing importance. Whereas in the past a country village, cut off by poor communications, had of necessity to grow most of its requirements, and did so independently of the suitability or otherwise of local soils and other factors, at the present day conditions of soil and climate determine much more what is economically possible.

It is interesting though by no means easy to break down the large figure for houses with gardens including allotments and for land agriculturally unproductive. In 1936–39 acreage of allotments was officially given as 49 653 hectares (122 600 acres) in England and Wales, 1659 hectares (4100 acres) in Scotland. In 1942 during the Grow More Food campaign of the war the total increased to 72 439 hectares (179 000 acres). A rough estimate gave 185 182 hectares (457 240 acres) occupied by roads (public highways with a total length of 289 024 kilometres (179 630 miles) in 1937–38) and 101 000 hectares (250 000 acres) for railway and railway yards. R. H. Best and J. T. Coppock (*The Changing Use of Land in Britain*, 1962) attempted a more positive approach and found the total 'urban area' of Great Britain, including railways and roads, 1 648 595 hectares (4 070 607 acres) in 1950.

Stamp calculated a round total of 1 861 500 hectares (4 600 000 acres) in 1960–61.

Best calculated that from 1900 to 1950 7 per cent of all agricultural land passed to urban uses.

## The classification of land

When the British Government declared its policy of conserving good agricultural land wherever possible for food production, the classification of land assumed a major practical importance which has since been accentuated by the development of town and country planning. Under the Act of 1947 it is compulsory on every county and county borough to prepare development plans. Inherent land quality must not be confused with productivity, which may vary greatly under different forms of management but in a long settled country such as Britain present and past use usually affords a useful pointer to potential use.

A simple tenfold classification into types of land was developed as a result of the work of the Land Utilisation Survey. It is described in detail in *The Land of Britain* and was reached after extensive discussion with the soil scientists. A map on the scale of 1:625 000 (Land Classification) was published in two sheets in the National Planning Series.

*Classification of types of land*

| | | |
|---|---|---|
| I Good | 1(A) | First Class General Purpose Farm Land, capable of intensive cultivation, especially of vegetables and fruit for direct human use. |
| | 2(AG) | Good General Purpose Land, suitable for cash crop production. |
| | 3(G) | First Quality Land, but with a high water table or liable to flooding. |
| | 4(G) | Good Land, but heavy. |
| II Medium | 5(AG) | Medium Quality Light Land, including Downland, Basic Grassland with certain areas suitable for arable cultivation (usually light land). |
| | 6(AG) | Medium Quality, General Purpose Farmland, which is or can be productive whether under crops or grass. |
| III Poor | 7(G) | Poor Quality Heavy Land. |
| | 8(H) | Mountain Land, Mountain or Rough Hill Pastures. |
| | 9(H) | Poor Quality Light Land (Lowland Heaths and Moors). |
| | 10 | Saltings, Rough Marsh Pasture, Wastelands, etc. |

A, G, H, indicate suitability for arable, grassland, or heathland.

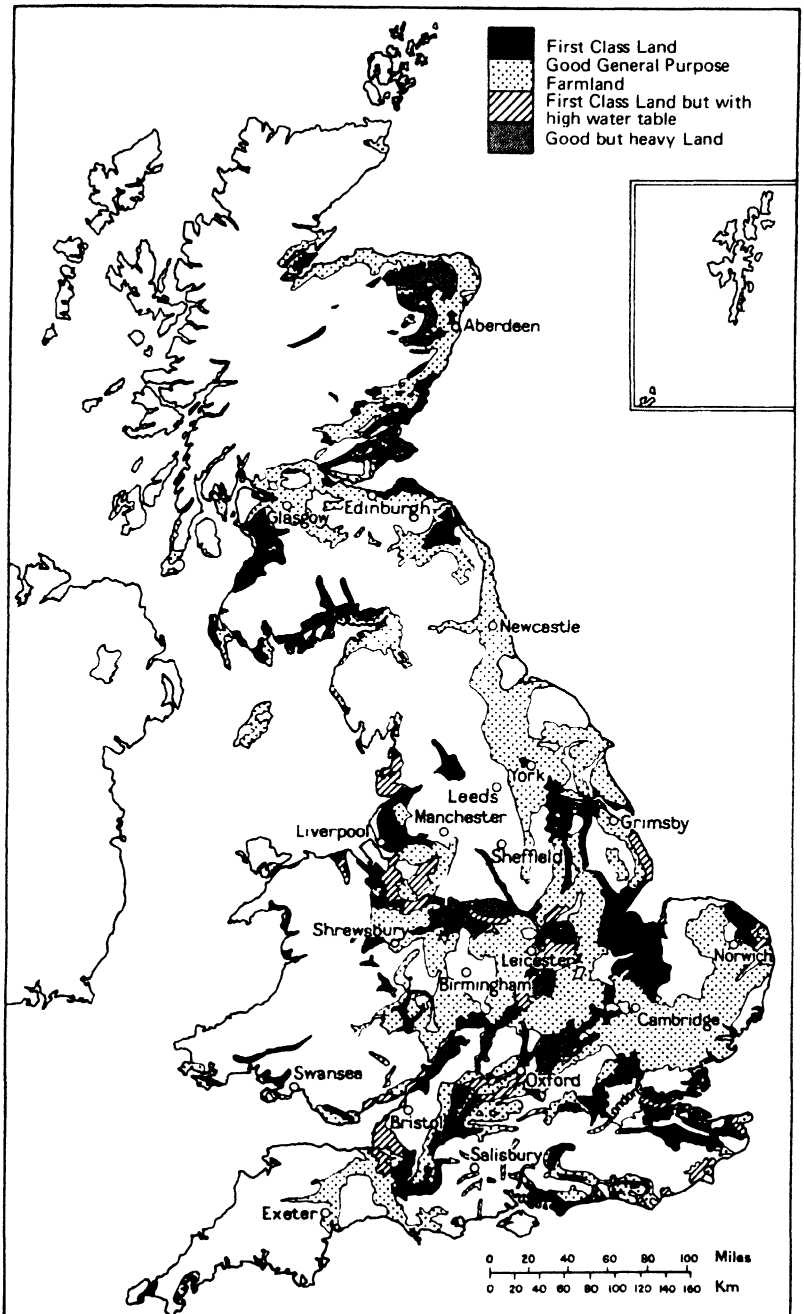



FIG. 82. Map showing distribution of the good agricultural lands of Britain

*Proportions of land of different types in Britain*

| | ENGLAND AND WALES | SCOTLAND | BRITAIN |
|---|---|---|---|
| I *Good* | *47.9* | *20.8* | *38.7* |
| 1 | 5.3 | 2.1 | 4.2 |
| 2 | 26.0 | 10.1 | 20.6 |
| 3 | 3.3 | — | 2.2 |
| 4 | 13.3 | 8.6 | 11.7 |
| II *Medium* | *32.0* | *15.1* | *26.3* |
| 5 | 7.0 | 0.4 | 4.8 |
| 6 | 25.0 | 14.7 | 21.5 |
| III *Poor* | *17.0* | *63.5* | *32.8* |
| 7 | 2.2 | 0.3 | 1.6 |
| 8 | 12.1 | 62.9 | 29.3 |
| 9 | 2.2 | 0.3 | 1.5 |
| 10 | 0.5 | 0.0 | 0.4 |
| Residue—Built over, etc. | 3.1 | 0.6 | 2.2 |

## The Second Land Utilisation Survey of Britain

During the 1960s a Second Land Utilisation Survey has been organised by Miss A. M. Coleman to continue and develop the work of Stamp's survey. The field mapping has again been carried out largely by volunteers using six-inch maps but it has been possible to publish the results in greater detail than previously, using the Ordnance Survey's postwar 1 : 25 000 series as a base. Most of the sixty-four categories portrayed are subdivisions of Stamp's original categories, but in addition there are four new classes: transport, unvegetated land, derelict land and recreational and other tended but unproductive land.

By the beginning of 1969 the field survey had been completed for England and half of Wales and 110 sheets covering 13 per cent of their area had been published. A separate Scottish committee is organising field mapping in Scotland and one sheet had been published.

The task of data analysis, using a computer, is being taken up. A preliminary interpretative analysis has organised the sixty-four categories within the framework of a general land use model, which recognises that the land of Britain consists of five basic land use territories, as follows:

Townscape—fully urbanised areas;
Farmscape—areas of viable agriculture, including villages;

Wildscape—areas of indeterminate use (i.e. intermittent uses, multiple uses or uses lacking visible boundaries) where use-mapping has to give place to the mapping of cover types;

Rurban fringe—the zone of confrontation and conflict between townscape and farmscape or less commonly between townscape and wildscape; the rurban fringe is usually relatively inflationary and in need of planning control;

Marginal fringe—areas of marginal farming, which typically occupy the zone between the farmscape and wildscape; the marginal fringe is usually relatively depressed and in need of planning assistance.

# 10
# Agriculture[1]

While in some ways the British Isles form an agricultural unit they cannot easily be treated as such in any geographical analysis, for much of the available information relates only to parts of the United Kingdom, and somewhat different policies have been pursued in the Irish Republic from those adopted in the United Kingdom. The emphasis in this chapter will be mainly on the latter country, and especially on Great Britain; more detailed discussion on Ireland will be deferred to Chapters 29 and 30.

It is important at the outset to appreciate the place which farming has come to occupy in the British economy. In the course of the great industrial expansion of the Industrial Revolution, British exports of manufactured goods and investment in overseas territories increased greatly; in return, imports of foods and raw materials grew in volume. Up to the period of high farming in the 1850s and 1860s, British agriculture had been able to feed the industrial population in the rapidly growing towns, but, with the repeal of the Corn Laws in 1846, barriers to exclude foodstuffs grown in other countries were reduced and finally eliminated. Although the effects of these measures were delayed, the rapid expansion in food imports which followed, especially with the agricultural colonisation of the temperate grasslands of the New World and Australasia, brought profound changes in British agriculture and reduced it to a severely depressed condition by the 1930s, producing only one-third of the food supply of an admittedly much larger population. This policy of cheap food certainly benefited those living in towns, who represented the majority of the population from the middle of the nineteenth century onwards; but owners of rural land, farmers and farm workers undoubtedly suffered. Largely because of the expansion of other sectors of the economy, agriculture's contribution to the gross national product declined in relative importance from about one-fifth in 1850 to about 3 per cent in the 1960s; at the same time there was a steady movement of labour out of agriculture, which now employs less than 4 per cent of the occupied population. The proportion is still considerably higher in Ireland, which was much less affected by industrial development. In the Irish Republic, 35 per cent of the employed population was engaged in

1. This chapter has been completely rewritten by Professor J. T. Coppock, to whom I am deeply indebted (S.H.B.).

agriculture in 1961, and farming accounted for 24 per cent of the gross national product (though it must be remembered that over a third of those born in Ireland are working in the United Kingdom, mainly in non-agricultural occupations); even in Northern Ireland, agricultural employment still accounts for 13 per cent of all employment.

Nevertheless, despite these changes in the relative position of agriculture, it would be quite wrong to consider British farming as unimportant, even in the depression years of the 1930s. The value of produce sold off farms at that time was ten times that produced by the fishing industry, and was greater than the output of the mining industry; and, despite the movement out of farming, agriculture still occupied more people in the United Kingdom than in any of the great agricultural exporting countries of the Commonwealth, such as Australia and Canada. Furthermore, as agriculture's share of employment decreased, its dependence on those employed in non-agricultural occupations, like the manufacture of machinery and fertilisers and the processing of agricultural produce, increased; so that while agriculture in the 1930s employed only 6 per cent of the occupied population, it was estimated that one in ten of the population was dependent on the land directly or indirectly for a livelihood. Agriculture also remains the largest user of land; if rough grazings are included as farmland, the proportions in England, Wales, Scotland and Northern Ireland are respectively 78, 84, 80 and 81 per cent, and that in the Irish Republic 84 per cent, an average of about 80 per cent for the whole of the British Isles.

Although agriculture's share of employment and production has continued to decline since the 1930s, the position of agriculture has greatly improved in recent decades. The government of the United Kingdom has come to accept a large measure of responsibility for the state of British agriculture through a complex system of production grants and guaranteed prices, minimum wage rates, and an increasing degree of control over food imports. Free trade was abandoned in the early 1930s, and in recent years governments have been increasingly concerned, chiefly through voluntary agreements with overseas suppliers, to restrain the value of food imports. At the same time, what has been called the second agricultural revolution has led to greatly increased productivity, despite a reduction of some 3 per cent in the area of agricultural land and of 35 per cent in the number of farm workers, so that British agriculture now supplies half the country's food requirements (or two-thirds of those products which could be grown in temperate latitudes) for a population more than twice as large as in the 1850s and a seventh larger than in the 1930s. The Irish government has similarly intervened in Irish agriculture, although here the situation is rather different, for the population of Ireland is less than two-thirds of that in the mid-nineteenth century and Ireland is a net exporter of foodstuffs; consequently there have also been measures to expand agricultural exports, which accounted for 59 per cent of all exports in 1961, dropping to 55 per cent in 1967.

## The development of agriculture in the British Isles before the First World War

The agricultural colonisation of the British Isles is the counterpart of the destruction of the natural vegetation which was discussed in Chapter 7, although, as has been shown, interpretation of the processes whereby the present agricultural landscape came into being is complicated by both physiographic and climatic changes, so that evidence of former limits of cultivation must be viewed with caution. The sequence of events is highly complex and only the broadest outlines can be sketched here; furthermore, changes in highland Britain, where conditions have generally been less suited to the growth of crops on account of the heavier rainfall, lower summer temperatures and often shorter growing season, have been rather different from those in lowland Britain, although recent research has shown that some of the differences between the mainly pastoral west and the arable east are less clearcut than was thought formerly.

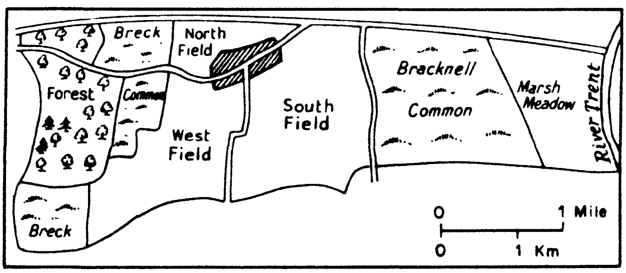



FIG. 83. A Nottinghamshire parish before enclosure, showing the nucleated village, the three fields, the waterside meadows, the common or waste lands and the woodland

In lowland England attention was first directed to the areas of light soil, perhaps because they were more easily cleared and because the heavier soils could not readily be cultivated with the equipment then available; but, especially from the fifth century with the coming of the Anglo-Saxons, the heavier soils were increasingly cleared for cultivation. Throughout much of lowland England the basis of colonisation was the nucleated village and its associated farmlands, which fell broadly into three categories: the common arable fields, the meadows and the waste. The large open arable fields were divided into strips, each of which represented part of the holding of an individual farmer, and were cropped on a common rotation. Where there were three fields a triennial rotation was practised, with one field under a winter corn crop (wheat or rye), one under a spring corn crop (barley, oats, peas or beans) and one under bare fallow; where there were two fields, crops and fallow alternated. Fields were cultivated in common and after harvest were thrown open for the farmers' livestock to graze the weeds and stubble. The meadowland was often sited on low-lying land

near a stream and was used for the production of hay; it too was thrown open for common pasturage after the hay harvest. Grazing was also provided in the waste, the land which had not yet been cleared for agriculture, although grazing animals, by preventing the regeneration of trees, must have contributed materially to the clearance of the natural woodland and to its replacement by heath and moor and ultimately by farmland. Those who held land were generally entitled to a share of such grazing and often possessed other common rights, such as the cutting of turf and brushwood for fuel, the cutting of bracken for litter, the quarrying of stones for house-building and the like. Figure 83 shows the layout of the farmlands of a Nottinghamshire village before enclosure and some idea of the appearance of such a village can be obtained by visiting Laxton in Nottinghamshire, where the open fields (though not the scattered strips) still survive.

Such an economy was primarily a subsistence one, wheat and rye being the bread grains, barley the basis of beer, and cattle, pigs and poultry providing meat; sheep were especially important for their wool, while oxen were the main work animals. There was thus a variety of products, a characteristic of much British farming which has persisted to the present day; but yields were very low, with perhaps 6.5 quintals of wheat per hectare (ten bushels per acre), a fivefold increase, rather more for barley and less for oats. Livestock production was also low, for the quality of grazing was poor and there was little fodder for winter; as a result, large numbers of animals were killed in the autumn and salted down to provide a supply of meat. Moreover, since the livestock were herded together and tended by the village cowherd, shepherd or swineherd as the case might be, improvement of livestock was difficult, as was that of crops grown in the common fields.

Land was held under the feudal system by which all land rights devolved in theory from the Crown and were granted by the Crown to tenants-in-chief, who in turn sublet to various classes of lesser tenants in exchange for services. Originally feudal superiors had held strips in the common fields and grazed their livestock in common with those of lesser tenants, but gradually they came to consolidate scattered strips and to enclose them and also to enclose land direct from the waste. Lesser tenants, too, consolidated holdings, perhaps also commuting their obligations to their feudal superiors for money rents which came in time to replace feudal obligations. From quite early on the system which has been briefly described began to break down, in part because fields were enlarged in size and increased in number as new land was cleared for agriculture, but also because of the tendency to enclose land for individual use. This process was facilitated by depopulation during the Black Death in the fourteenth century, while during the Tudor period the high price of wool made it advantageous for landlords to enclose land and lay it down to grass; as M. W. Beresford has shown, whole villages were depopulated and replaced by large fields for grazing. Nevertheless, half the arable land in England and Wales was still in open fields by the middle of the eighteenth century. In the next hundred

years all but a handful of these disappeared under a succession of Acts of Parliament, to be replaced for the most part by regularly-shaped fields, bounded by hedges, and compact holdings in individual occupation which were normally held on lease from a large landowner. On the larger holdings, too, new farmhouses and steadings were often built in the farm territory away from the village. Large areas of heath and down were also brought into cultivation at this time and laid out in farms, generally with steadings dispersed among the fields.

The situation which has been described was most characteristic of the country between the estuary of the Tees and that of the Exe, but in many other parts of the lowlands, open fields, if they ever existed, disappeared early and the agricultural landscape has long been enclosed. Both customs of land holding and physical conditions contributed to these contrasts; in the Chilterns, for example, where there is little level land, open fields were small and complex and soon disappeared, so that Leland in the seventeenth century contrasts the 'champion' (open) Vale of Aylesbury and the Chilterns 'full of enclosures'. In Scotland, Ireland and some areas of poor land in England, the arable land was farmed on the infield/outfield system which resembles shifting cultivation or bush fallow in that some land, the outfield, was cropped intermittently and allowed to revert to rough vegetation until its fertility was restored, while other land, the infield, was continuously cultivated and manured. Such land was unenclosed and farmed in scattered strips. In Scotland much of it remained in this condition until the end of the eighteenth century, when, in a period of less than fifty years, it was rapidly transformed into a landscape of enclosed fields and individual holdings. Most infield/outfield farming in Ireland had also disappeared by the nineteenth century. Throughout these areas of highland Britain, there is increasing evidence to show that the present pattern of dispersed farms was preceded by one of small nucleations, surrounded by small arable fields divided into strips, on which subsistence crops would be grown.

The extensive rough grazings of the uplands of highland Britain were also grazed in common and were generally managed on a system of transhumance, whereby temporary summer dwellings were occupied while mixed flocks of sheep and cattle grazed the pastures, to be abandoned in winter for a permanent settlement at lower altitudes. From the sixteenth century onwards large scale sheep farming, begun by the Cistercian monasteries in the Pennines, gradually extended to these upland areas, reaching north Scotland in the early nineteenth century. As a result, the summer grazing by mixed flocks was replaced by a monoculture of sheep and by the nineteenth century nearly all the uplands were being grazed throughout the year by sheep. The common grazings have disappeared in a variety of ways and in England and Wales large areas were enclosed by Act of Parliament between 1750 and 1900, although approximately 0.6 million hectares (one and a half million acres) of common land still survive. In

Scotland and Ireland common grazings mainly disappeared without legislation, although they survive in the crofting areas of Scotland and in parts of the Irish uplands.

Towards the end of the sixteenth century there was increasing trade with other parts of Europe, especially Flanders, and largely as a result, new crops and livestock and new methods of farming came to be introduced into lowland England. Turnips, clover and fodder grasses were the most important of these; because of the capacity of the bacteria in the root nodules of clover to fix atmospheric nitrogen, clover improves the fertility of the soil, while clover, grasses and turnips provided a supply of winter feed for livestock. There evolved the Norfolk four-course rotation (and variants of it) especially on light land; under this rotation, wheat is succeeded by a root crop, mainly turnips, then by barley and finally by a leguminous crop. As a result yields increased greatly, and by the middle of the eighteenth century, that of wheat had doubled to some 13 quintals per hectare (20 bushels per acre). Enclosure and associated improvements in crop husbandry enabled both tenants and owners to carry out controlled experiments in animal breeding; from these emerged the breeds of sheep, like the Leicester and the South Down, and of cattle, like the Hereford and Shorthorn, which are now important in the major wool- and meat-producing regions of the world. Much of this work was done by tenant farmers, but it was often the enthusiasm and enterprise of the great landlords that created the necessary conditions. These improvements were slow to be adopted in Scotland, where farming remained backward until the late eighteenth century; they then spread rapidly, and Scottish farming, especially in the eastern Lowlands, came to be known for its high standards of husbandry.

The early Victorian period was one of great scientific progress in British farming. The requirements of the different crops came to be scientifically studied and the use of artificial fertilisers began to spread. The first consignments of nitrate of soda arrived in 1830 and of Peruvian guano about 1840, while in 1843 Lawes, who founded Rothamsted Experimental Station in Hertfordshire, began the manufacture of superphosphate at Deptford and quickly proved the value of ammonia salts (which could be made easily from byproducts of the already important gas industry) as fertilisers for crops. Land drainage received scientific study; tile drains, available from the 1830s, were extensively used for underdraining, and this led to considerable improvement in the productivity of heavy land. Imported feeding stuffs for livestock, such as linseed and cottoncake, also came to be widely used, improving livestock nutrition and, in effect, importing the fertility of other lands. As a result crop yields increased and that of wheat had risen to 20 quintals per hectare (30 bushels per acre) by 1870. The demands of the expanding industrial towns were also a stimulus to improvement and the rapid development of the railway network between 1840 and 1870 brought many areas within easy access of urban markets. These years are sometimes spoken of as the period of high farming, when the area of im-

proved land probably reached its greatest extent ever and land was farmed intensively for high profits.

This remarkable period of agricultural prosperity and development came to an end about 1874. High prices had been occasioned by the Franco-Prussian War of 1870–71, but this was followed by a trade depression and a series of bad seasons. A new factor came into operation, the growth of railway networks overseas and the development of steamship traffic, which greatly facilitated international trade in agricultural produce. Rapid settlement of the new lands in Canada, the United States, Argentina and Australia soon followed, and supplies of foodstuffs from these regions began to appear in quantity. As a result, the prices received for domestic produce fell sharply and continued to do so until the end of the century. Wheat was the first to suffer, but meat prices followed as refrigeration enabled distant countries like New Zealand, Australia and Argentina to compete in British markets. However, the decline in meat prices not only began later, it was also less severe. Increasing imports of dairy produce, especially cheese, also had an adverse effect on the prices received by British farmers.

Unlike their counterparts in other European countries, many of whose governments erected tariff barriers to keep out the flood of cheap food, British farmers were left to fend as best they could. Those most severely affected were farmers who depended on wheat, which was the chief cash crop in most of the principal areas of arable farming. Even these parts of the British Isles were not as well suited to wheat growing as the temperate grasslands, nor could British farmers grow the hard wheats which were desirable for breadmaking; consequently, they were unable to compete with the produce of these more favoured lands. Low prices led farmers to economise by laying land down to grass and by neglecting necessary cultivations; rents were reduced because farmers could not pay them and landowners were consequently deprived of the resources to make necessary changes in order to accommodate new systems of farming, and large areas could not be let and were extensively farmed by landowners. It was particularly in areas of heavy or poor land in central and eastern England that the greatest changes took place.

As far as possible, farmers tried to adopt systems of farming which were economical and were less severely affected by competition from imported produce. Livestock farming increased in importance because it was less expensive of labour and because meat prices had fallen less than those of cereals, and the rapidly growing towns and the general rise in living standards provided new demands for milk and vegetables. Milk consumed fresh enjoyed a natural protection against competition, although that manufactured into cheese and butter competed with imported produce. Up to the middle of the nineteenth century, milk had been produced either in town dairies, with stalled cattle fed on purchased feed, or on the immediate outskirts of towns; but improved transport and developments in the technology of milk treatment extended the distance over which milk could be

carried, and dairying was adopted by farmers whose systems of farming had become unprofitable, while those in traditional dairying areas, who had formerly concentrated on the production of butter and cheese, turned increasingly to milk production. So great was the increase in dairying along the Great Western Railway line to Wiltshire that it was said to be known as the 'Milky Way'. Market gardening also developed, both around the towns and, with the aid of railways, in more distant localities, like west Cornwall, the Fenland and mid-Bedfordshire; in the latter area, there was a two-way traffic of vegetables to London and manure from London work-horses which helped to improve these light soils. Increasingly, too, arable farmers grew vegetables to provide an additional cash crop, so that the once clearcut distinction between farming and market gardening began to break down.

These changes affected primarily eastern and midland England; elsewhere the emphasis was already mainly on pastoral farming, although even in these areas there was a tendency for marginal land to revert to rough grazing and for the general level of farming to deteriorate. Rural depopulation became widespread and was especially severe in Ireland, where the acreage under crops was more than halved.

## The interwar years

In the early years of this century the position of British agriculture improved somewhat, for many of the necessary adjustments had been made and the downward trend of prices had slackened and was reversed during the blockade of the First World War, when the government adopted measures to increase the home supply of food. Mechanisation, though still on a small scale, was encouraged and administrative machinery established to stimulate production and to increase the acreage under crops, both by guaranteeing minimum prices for the main products and by means of county agricultural committees, whose tasks included indicating what land should be ploughed. As a result, the area under tillage in the United Kingdom rose by 1.25 million hectares (3.1 million acres). This achievement was shortlived and the downward trends were resumed after the war. Although some attempts were made in the 1925 British Sugar (Subsidy) Act, which provided a subsidy for homegrown sugar, to improve the position of arable farmers by providing them with an alternative cash crop, this was an isolated incident and government still stood aloof from farming apart from the promotion of research and the enforcement of health regulations.

This situation was greatly changed by the worldwide depression of the early 1930s. The policy of laissez-faire was abandoned and a variety of measures adopted to protect the British farmer and to improve his bargaining position. Agricultural products, with the exception of those from Empire sources, had to face import duties and, in the case of horticultural

crops, these varied seasonally depending on the marketing of the home crop; attempts were even made to regulate the volume of imports. Guaranteed minimum prices were also introduced for wheat and fat cattle and, from the late 1930s, the first of a number of production grants was introduced, to subsidise the liming of land; with war imminent in 1939, a grant was also made available for the ploughing of grasslands. Although the wheat subsidy did result in a sharp, but shortlived, increase in the wheat acreage, it cannot be said that any of these measures had a marked effect on trends in British agriculture. The area under tillage continued to decline, although this was in part due to the loss of land to non-agricultural uses, which was running at the rate of 20–25 000 hectares a year in England and Wales alone in the 1930s. Perhaps the most significant change was that introduced by the Marketing Acts which allowed agricultural producers to form statutory marketing boards in order to promote the orderly selling of produce. Boards were established for hops, milk, pigs and potatoes, but their fates and their powers were very varied. The most important were the Milk Marketing Boards, especially that established for England and Wales. By acting as a sole buyer and seller of milk, the Board was able to prevent the price of milk manufactured into butter, cheese and other products from undercutting the price of milk sold liquid. Furthermore, by a system of interregional levies, the more remote producers were subsidised by those nearer the markets, so that some of the advantages of proximity were reduced. This fact, together with the certainty of a market for milk at a known price and the attraction, particularly for the small farmer, of a regular monthly income, encouraged an increasing number of people to take up dairying; between 1933, when the Board was established, and 1938 the volume of milk sold by the marketing boards increased by 30 per cent.

From the 1870s until the 1930s certain broad trends can be discerned. Over most of the country it had become uneconomic to grow crops when there were regularly available supplies from overseas countries where physical conditions and farm structure were often more favourable. As a result, the area under pasture steadily increased, except where most of the land was already down to permanent grass or where conditions were most suitable for crop growth and were least favourable to livestock farming, as in eastern parts of lowland Britain. At the same time, numbers of cattle increased steadily throughout the country, while those of sheep remained fairly stable, and sheep became increasingly concentrated in upland and grassland areas because of the high labour costs of keeping them under arable systems.

## The Second World War and after

Although the measures adopted by the government in the 1930s represented an important change in attitude, the Second World War is the

watershed between the agriculture of the depression years and that of today. When war began, plans which had been prepared for the expansion of home food supply were rapidly implemented, largely through the agency of County War Agricultural Executive Committees which provided assistance and advice to farmers, for example through the loan of machinery, had powers to prescribe cropping and to take over and work land where this was being neglected. Considerable attention was paid to the upgrading of agricultural land through clearing, ditching and draining, and between 1940 and 1950 grants were paid to improve 2.8 million hectares (seven million acres) in England and Wales. Fields which had been infested with scrub were cleared and considerable tracts of moorland and heathland reclaimed.

The key element in wartime policy was an increase in the acreage of ploughed land, for this was more productive than permanent grassland and more flexible in its use, in that many crops could be used either for direct human consumption or for feeding to livestock. With considerations of nutrition and import-saving in mind, emphasis was placed upon greater production of grain, potatoes, sugar beet and milk. Meat production, which is expensive of land, was reduced and the numbers of sheep, pigs and poultry declined. The use of machinery was greatly accelerated; for example, there were less than 50 000 tractors in Great Britain in 1939, most of them in eastern England, but by 1946 there were over 200 000 and these were much more widely distributed throughout the country. Consumption of fertilisers, too, rose dramatically and, by recruiting members of the Women's Land Army and employing prisoners of war, the total labour force was actually increased. As a result of all these measures, the supply of homegrown wheat increased by approximately a third, the acreage under potatoes doubled and production of fodder crops rose by a third; on the other hand, supplies of meat fell by a third and those of eggs by a half. Net farm output as a whole increased by 20 per cent between 1939 and 1944, but the gross increase was rather smaller (5 per cent), partly because much of the output was required to replace imported feedingstuffs and store stock.

The effects of war time measures were widely felt. As Figs 84 and 85 show, the greatest proportional increase in the extent of arable land was in the midland and western counties of Great Britain, where the arable acreage was formerly small; in most Welsh counties, for example, there was more ploughed land in 1944 even than in the 1870s, although the total acreage in the United Kingdom was 2 per cent lower than that in 1871. In eastern counties of Great Britain, where most of the farmland had remained under the plough, the scope for increase was more limited, but even here there was a large expansion in the acreage of ploughed land, especially on heavy land like the clays of Essex and west Cambridgeshire, where poor arable land had tumbled down to grass in the period of agricultural depression.

The campaign to increase agricultural production in wartime also saw

a considerable extension of state aid to agriculture. Prices for agricultural produce were fixed at levels which would encourage production, grants were made towards the cost of improvement and recognition was given to the needs of particular types of farming for special help in the provision of subsidies on hill sheep. In the postwar period these measures were extended and consolidated into a comprehensive policy of state support for agri-

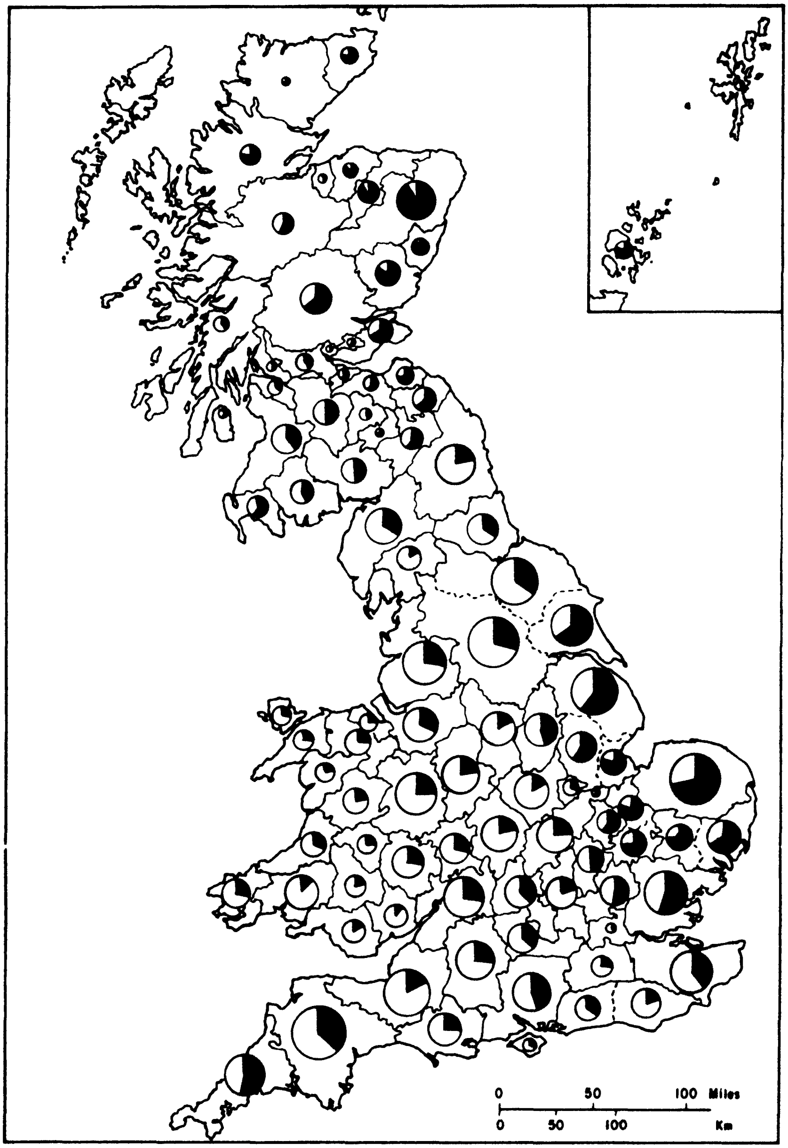



FIG. 84. The use of farm land in Great Britain, 1937

This map shows that arable land was mainly important in the drier counties of eastern England and in Scotland. Each circle shows area of arable land in black, permanent grass white.

culture. It was accepted in the 1947 Agriculture Act that the government of the United Kingdom had a duty, not only to promote a stable and efficient agriculture which would provide an appropriate part of the nation's food supply at competitive prices, but also to ensure that the levels of living of those engaged in agriculture were comparable to those enjoyed by the rest of the community and that landowners received an adequate return

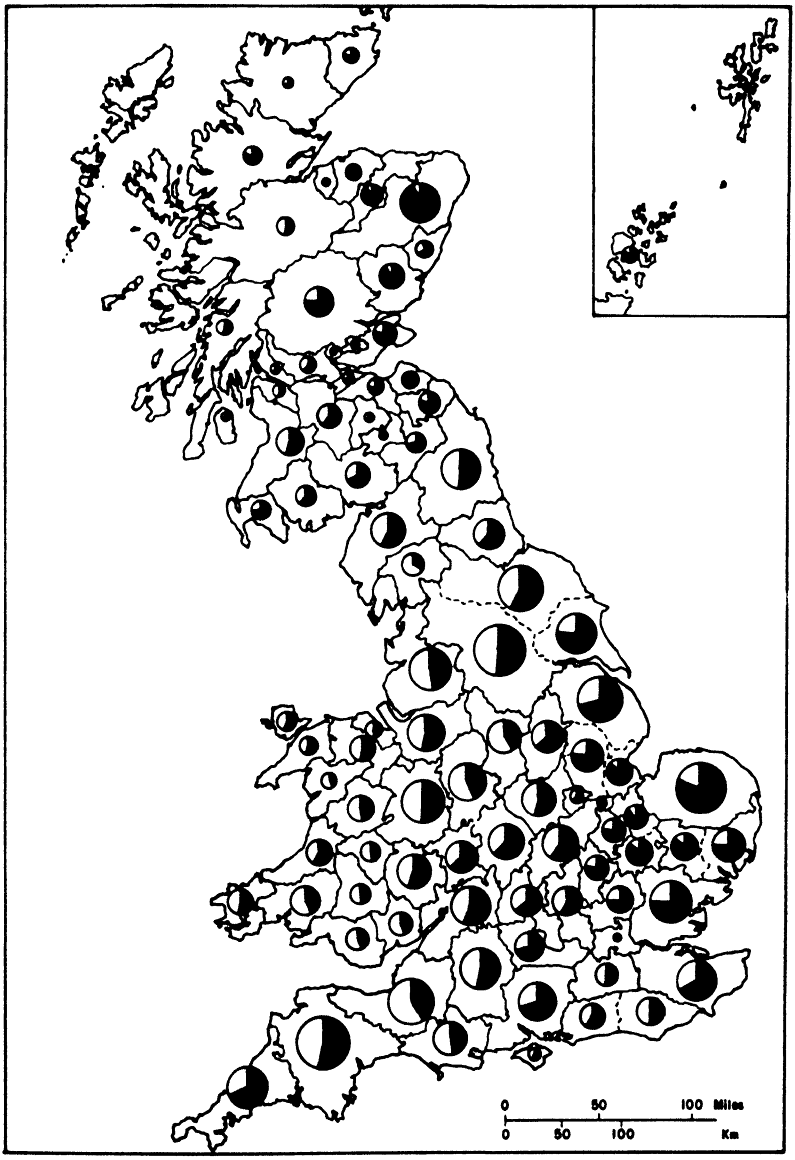



FIG. 85. The use of farm land in Great Britain, 1944
This map shows the effect of the wartime ploughing campaign.

on the capital they invested in the industry. The main method of achieving these aims was by means of an annual review of prices, at which the ministers responsible for agriculture considered changes in agricultural costs and supplies and determined a level of guaranteed prices for the main agricultural products in the succeeding year. For the most part these guarantees were implemented by deficiency payments, i.e. the difference between the actual price achieved on the free market and the guaranteed price, although the production of oats and barley was supported by acreage payments. In addition there was a variety of production grants to encourage desirable practices, like the grassland ploughing, lime and fertiliser subsidies; grants were also payable towards the cost of land improvement and drainage, to promote the production of particular commodities, like the calf subsidy, and to assist the farmers in areas which did not benefit directly from guaranteed prices, like those producing store cattle and store sheep on the upland margins.

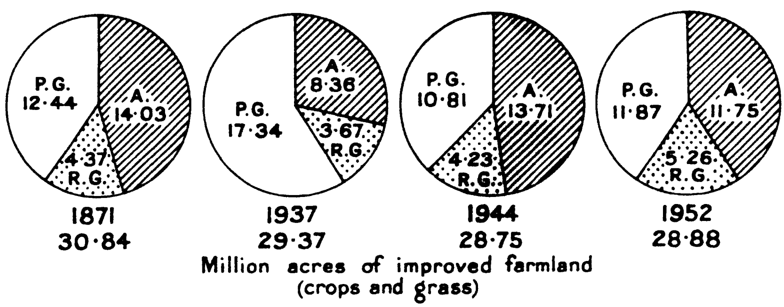



FIG. 86. The changing use of farmland in Great Britain, 1871–1952

The postwar period can be broadly divided into two in respect of government policy. Until the mid-1950s, the emphasis was on increasing agricultural production and in the later period on efficient production. After the war, a worldwide food shortage and problems of foreign exchange to pay for imports led governments to encourage production by favourable prices with the aim of achieving a level of production 50–60 per cent above that of prewar. During the 1950s, however, surpluses of certain commodities began to appear and the total cost of subsidies grew till it was approximately as large as net farm income. The emphasis therefore switched to production at competitive prices and guarantees for some commodities have even been reduced, although, under the 1957 Agricultural Act, the Government sought to provide a measure of stability by undertaking that both the total subsidy bill and the level of guaranteed prices for individual commodities should vary only within quite narrow limits from year to year. Attempts have been made to shift an increasing proportion of the subsidy bill to production grants, and the Government have also sought to limit their commitment to pay subsidies on some commodities by nominating standard quantities to which the guaranteed prices apply and to limit the

volume of imports of competing products by voluntary agreement with the overseas producers. Increasing involvement by Government in the determination of agricultural production in the United Kingdom is thus one of the most distinctive features of the postwar period. The increased emphasis on efficient production has led farmers to simplify farming systems, and has contributed to the pressures to enlarge farms in order to achieve a satisfactory standard of living and to make the most efficient use of resources, especially machinery and labour. Governments have directly assisted this process through the Small Farmers' Scheme, introduced in 1958, which has provided grants towards the cost of reorganising those small holdings which are thought capable of providing an adequate income and through recent legislation which has encouraged the amalgamation of farms which are not viable and provided compensation for elderly farmers who are willing to retire.

The other major feature of British farming in the postwar period has been the rapid rate of technological change, summed up in the phrase 'second agricultural revolution'. The trend towards greatly increased mechanisation begun during the Second World War has continued and, although the number of tractors has changed little since the late 1950s, there has been a sharp increase in other kinds of mechanical equipment; the stability in numbers of tractors also conceals a steady replacement by larger and more powerful machines. Tractors are now widely found

PLATE 4. Combine harvesting of barley on Salisbury Plain, Wiltshire

throughout the United Kingdom and serve not only to draw tillage implements, but also as a means of farm transport and even of personal transport in hill areas. As a result, the horse as a work animal has virtually disappeared from British farms and has ceased to be enumerated in the agricultural censuses in Great Britain; an interesting byproduct of this change has been the release of land, estimated at between 1.2 and 1.6 million hectares (three to four million acres), which was formerly needed to support these work animals. The use of lime and fertilisers, encouraged by government subsidies, has become much more widespread and applications of lime have increased sixfold since 1939 and those of nitrogenous fertilisers almost eightfold. Plant breeders have produced new varieties with high yields, greater resistance to disease and often adapted to particular environments; the great expansion in barley growing since the Second World War owes much to the development of new varieties. The use of pesticides and herbicides to combat plant pests and diseases has also increased greatly and once common weeds of cereal fields like the cornflower and the poppy are now almost extinct. Similar developments have occurred in animal husbandry from better understanding of management and nutrition, from the use of chemicals both to promote growth and to control disease, and through the development of artificial insemination, which enables the influence of high quality stock to be felt much more widely; less than half the cattle born in the United Kingdom are now the product of natural mating. As a result of these changes agricultural production has continued to rise steadily and in the United Kingdom is now almost double the level of prewar years, despite a continued reduction in the area of agricultural land through losses to housing and industry, mineral working, forestry and other uses, which are running at a rate of some 40 500 hectares (100 000 acres) a year, and a continued fall in the labour force which declined by 38 per cent between 1939 and 1967.

Changes are also taking place in marketing. A rise in the proportion of food which is processed and the growing share of food purchases made by chain stores, supermarkets and other large buyers has increased the importance of grading and packing; the encouragement to improve marketing and grading given by governments in exporting countries also provides an incentive to British farmers to improve the presentation of their products and to organise themselves in order to strengthen their bargaining position. Government support has been provided to help the reorganisation of horticultural marketing, and a Home Grown Cereal Authority and a Livestock and Meat Commission have been established to promote better and more orderly marketing of these products.

British agriculture today is in process of rapid change. Economic pressures and the needs of mechanisation are encouraging a move to larger farms and fields, especially in eastern arable districts. Farming systems are tending to become simpler, both from economic necessity and because the chemicalisation of agriculture appears to have removed the need for rota-

tions in the interests of crop hygiene, at least in the short run. With these trends are associated greater areal specialisation as agricultural enterprises show an increasing tendency to be localised in particular parts of the country. These trends can be expected to continue.

## The distribution of crops and livestock

The main features of agricultural land use have already been discussed in Chapter 9, but these now need to be placed in an agricultural context. When the first Land Utilisation Survey was undertaken in the 1930s there was a fairly clearcut division of agricultural land, in eastern England at least, into arable land and permanent grassland. In Scotland the distinction was more difficult to make because most rotations included a grass


FIG. 87. The chief arable areas of Great Britain

Main areas in black, mixed arable and grassland dotted. In England it is easy to see that the chief factor concerned is climate. In southern Scotland the same factor operates, but in the Highlands of Scotland it may be said that if the land is worth 'improving' from the main mass of moorland it is ploughed rather than put down to permanent grass.

crop which was left down for several years; in northeast Scotland, for example, a common rotation included three years of cereals and roots and three years of grass. In many western parts of Great Britain also much of the

improved land was periodically ploughed and returned to grass after one or more other crops had been taken. Since the Second World War, the acreage of temporary grass has greatly increased and such ley farming or alternate husbandry has become much more widely practised in England and Wales, assisted by the ploughing grants which were available between 1939 and 1967. Many of the grassy shires of midland England now show a wide scatter of ploughed fields which will soon be put down to grass and other grass fields ploughed in their place. As a result, it is now more useful to distinguish between the land under tillage crops, i.e. crops other than grass, and grassland, rather than between arable and permanent grassland, and this practice has been adopted in the Second Land Use Survey. (see above, p. 158).

Land under tillage crops is mainly concentrated in eastern parts of Great Britain, and this tendency has become even more marked in the 1960s than it was in the 1930s. The highest proportions, exceeding 80 per cent, are found in the Fenland, where there is little grass, and in general there is a gradient of a decreasing proportion of tillage from the drier east to the wetter west. Most of the exceptions to this rule can be explained in terms of soil and climate. Thus, the Welsh borderland lies in the rain shadow of the uplands, while southwest Lancashire has a low rainfall and free-draining soil; conversely, most of the areas in eastern counties with low proportions of agricultural land in tillage crops have heavy soils or suffer from poor drainage. The principal controls are thus climatic, for the drier conditions which tend to prevail in the east are better suited to the ripening and harvesting of crops; but, by a fortunate coincidence, most of the land which is well-suited by virtue of its altitude, relief and soil to mechanised crop production is also found in eastern counties (Fig. 87). These drier areas are also less suitable for grass, especially on the lighter soils where little growth is possible in dry seasons. The best grassland areas are generally those with the fairly heavy soils and moderate rainfall of between 900 and 1300 millimetres (35 and 50 in), as in Cheshire and Somerset. In wetter areas, high soil acidity is likely to affect the quality of the grassland adversely.

The distribution of grassland and tilled land in Ireland is rather similar in that most of tilled land is found in the east of the country; but, because of the higher rainfall, Ireland as a whole is less suitable for crop production and only in a small part of the southeast is more than 30 per cent of the agricultural land in tillage crops.

Cropping in the British Isles is dominated by cereals which together account for 76 per cent of the area under tillage crops; the remainder is made up of cash crops such as potatoes, sugar beet and vegetables, and by a variety of fodder crops, including turnips, kale and rape, which are consumed mainly on the farm of origin. The following table shows the acreage, yield and production of the main crops in the United Kingdom in 1938 and 1966.

*Area, yield and total product of the principal crops in the United Kingdom, 1938 and 1966*

| CROP | AREA | | YIELD | | TOTAL PRODUCE 1938 | |
|---|---|---|---|---|---|---|
| | (*thousand*) | | | | (*thousand*) | |
| Wheat | acres | 1 928 | cwt per acre | 20.4 | long tons | 1 965 |
| | hectares | 780 | kg per ha | 2 561 | metric tons | 1 996 |
| Barley | acres | 988 | cwt per acre | 18.3 | long tons | 904 |
| | hectares | 400 | kg per ha | 2 497 | metric tons | 918 |
| Oats | acres | 2 395 | cwt per acre | 16.6 | long tons | 1 992 |
| | hectares | 969 | kg per ha | 2 084 | metric tons | 2 024 |
| Potatoes | acres | 733 | long tons per acre | 7.0 | long tons | 5 115 |
| | hectares | 297 | metric tons per ha | 17.5 | metric tons | 5 197 |
| Turnips and swedes | acres | 753 | long tons per acre | 14.3 | long tons | 10 710 |
| | hectares | 305 | metric tons per ha | 35.7 | metric tons | 10 881 |
| Mangolds | acres | 219 | long tons per acre | 17.0 | long tons | 3 705 |
| | hectares | 88 | metric tons per ha | 42.5 | metric tons | 3 764 |
| Hay | acres | 6 406 | cwt per acre | 21.0 | long tons | 6 127 |
| | hectares | 2 592 | kg per ha | 2 636 | metric tons | 6 225 |

| CROP | AREA | | YIELD | | TOTAL PRODUCE | | |
|---|---|---|---|---|---|---|---|
| | (*thousand*) | | | | (*thousand*) | 1966 | 1968 (estimate) |
| Wheat | acres | 2 238 | cwt per acre | 31.2 | long tons | 3 496 | 3 515 |
| | hectares | 905 | kg per ha | 3 917 | metric tons | 3 552 | 3 571 |
| Barley | acres | 6 130 | cwt per acre | 28.7 | long tons | 8 809 | 8 274 |
| | hectares | 2 481 | kg per ha | 3 603 | metric tons | 8 950 | 8 407 |
| Oats | acres | 907 | cwt per acre | 24.4 | long tons | 1 102 | 1 212 |
| | hectares | 367 | kg per ha | 3 063 | metric tons | 1 120 | 1 231 |
| Potatoes | acres | 669 | long tons per acre | 9.7 | long tons | 6 476 | 6 738 |
| | hectares | 271 | metric tons per ha | 24.2 | metric tons | 6 580 | 6 846 |
| Turnips and swedes | acres | 300 | long tons per acre | 19.2 | long tons | 5 770 | 5 429 |
| | hectares | 121 | metric tons per ha | 48.0 | metric tons | 5 862 | 5 516 |
| Mangolds | acres | 42 | long tons per acre | 24.8 | long tons | 1 041 | 803 |
| | hectares | 17 | metric tons per ha | 62.0 | metric tons | 1 057 | 816 |
| Hay[1] | acres | 5 302 | cwt per acre | 31.9 | long tons | 8 468 | 8 395 |
| | hectares | 2 145 | kg per ha | 4 005 | metric tons | 8 604 | 8 742 |

[1] 1965.

## Wheat

The acreage under wheat in the whole of the British Isles in the year 1931 was 514 755 hectares (1 271 000 acres), the lowest ever recorded. Of this area, only 20 234 hectares (50 000 acres) were in Scotland and 9713 hectares (24 000 acres) in Ireland. The total production was about 1 046 000 metric

tons (1 034 000 long tons), compared with roughly 6 063 000 metric tons (5 968 000 long tons) which were imported in the same year. Following the abandonment of Free Trade in 1932 and the introduction of a guaranteed price for a specified quantity of wheat, the acreage in the United Kingdom rose to 780 840 hectares (1 928 000 acres) in 1938. Similar measures in Ireland led the acreage there to rise sharply to 103 275 hectares (255 000 acres). During the Second World War the area under wheat increased rapidly to a maximum of 1 402 925 hectares (3 464 000 acres) in the United Kingdom in 1943 and 268 110 hectares (662 000 acres) in Eire; the acreage under wheat has since declined to 906 390 hectares (2 238 000 acres) and 53 055 hectares (131 000 acres) respectively in 1966.

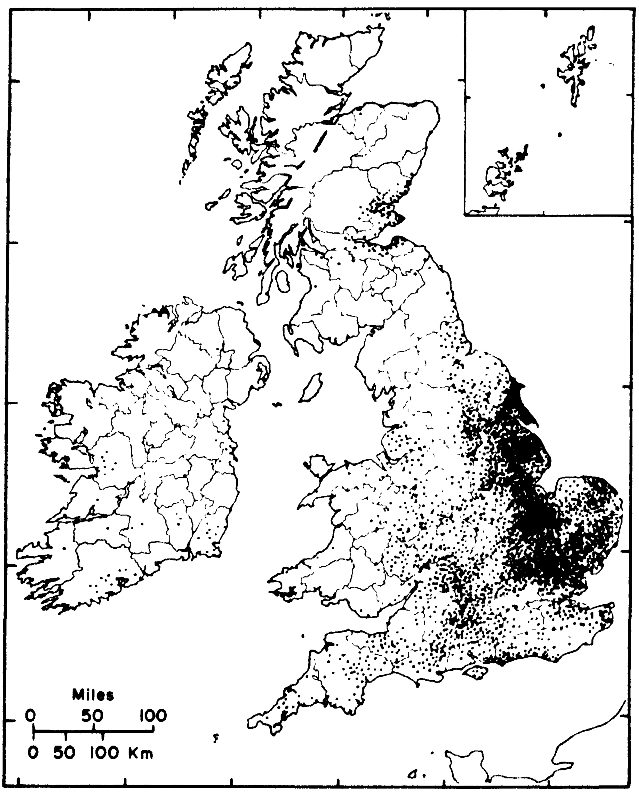



FIG. 88. Map showing the distribution of wheat cultivation in the British Isles

Each dot represents 500 acres in 1931, the year when acreage reached its lowest recorded and when wheat was being grown only where physical conditions were especially favourable.

Figure 88 shows the distribution of wheat in the depression year of 1931. It illustrates the remarkable concentration of wheat cultivation in East Anglia, which has the combined advantages of low rainfall, comparatively high summer temperatures and sunshine, large tracts of gently undulating

or level land suitable for ploughing, and fertile mixed soils. In Scotland the small acreage of wheat was restricted mainly to the south of the country and to its eastern margin, which also has a comparatively low rainfall of less than 760 millimetres (30 in). The northernmost extension of wheat cultivation was found on soils developed from the Old Red Sandstone around the Moray Firth. It is, however, broadly true that the 15.5°C (60°F) isotherm for the month of July roughly (see Fig. 54) marks the northern limit of significant wheat cultivation. The distribution of wheat growing in the British Isles thus suggests two quite different types of limit. Broadly speaking, it may be said that the possible limits of cultivation of any crop are determined by physical, primarily climatic conditions. So far as wheat is concerned, this ultimate limit is almost reached in the north of Scotland, and Caithness, Orkney and Shetland lie outside the limit; but the whole of Ireland, Wales and England, and the southern two-thirds of Scotland fall within it. However, as the ultimate limits for the cultivation of any crop are approached, there is usually a belt where harvests are uncertain and may fail completely in some years, although in others bumper crops of good quality may encourage farmers to gamble. There is thus a second limit of cultivation which may be described as the economic limit. Within this, natural conditions are such that an annual crop is generally assured and failures are rare. Here, too, a given crop can be grown in competition with others. In broad terms, the economic limit for wheat in the British Isles may be said to correspond with roughly the 760-millimetre (30-in) isohyet on the west and with the 15.5°C (60°F) July isotherm on the north, although there are specially favoured outliers. The whole of Ireland and Wales, much of western England, and the greater part of Scotland lay beyond these limits in the 1930s. It is true that in the nineteenth century and earlier when competition from foreign wheat was unimportant, this crop was grown in large quantities over the fringing tracts outside the economic limits of the 1930s, but conditions in that outer fringe were never near the optimum for wheat. It is frequently urged that the decline in wheat cultivation in such areas as Ireland is due primarily to economic and historical causes, but the truth would seem to be that Ireland, like many other countries, was producing a crop for which it was not climatically suited. Detailed agricultural statistics have been collected in Ireland since 1847 and in Great Britain since 1866 and the maximum acreages recorded under wheat are as follows:

| | | | |
|---|---|---|---|
| England and Wales | 1 378 620 hectares | (3 404 000 acres) | in 1871–75 |
| Scotland | 54 960 hectares | (135 700 acres) | in 1872 |
| Northern Ireland | 36 200 hectares | (89 400 acres) | in 1858 |
| Eire | 371 750 hectares | (671 000 acres) | in 1847 |

In Ireland, wheat has never been a crop of primary importance; in what is now Northern Ireland, it occupied only 8 per cent of the ploughed area even at the time of its maximum extension in 1858 and in the Irish Republic,

the proportion was even less. By contrast, even as late as 1925, wheat occupied 28 per cent of the total arable area in the English counties of Huntingdon and the Isle of Ely, where conditions approach as near as possible in this country to the optimum. Elsewhere, natural conditions were less favourable and, with a temporary halt in 1917–18, the acreage dwindled until positive action by governments in the 1930s halted the decline. During the Second World War the acreage in 1943 almost equalled that in 1871 and wheat was grown in every county.

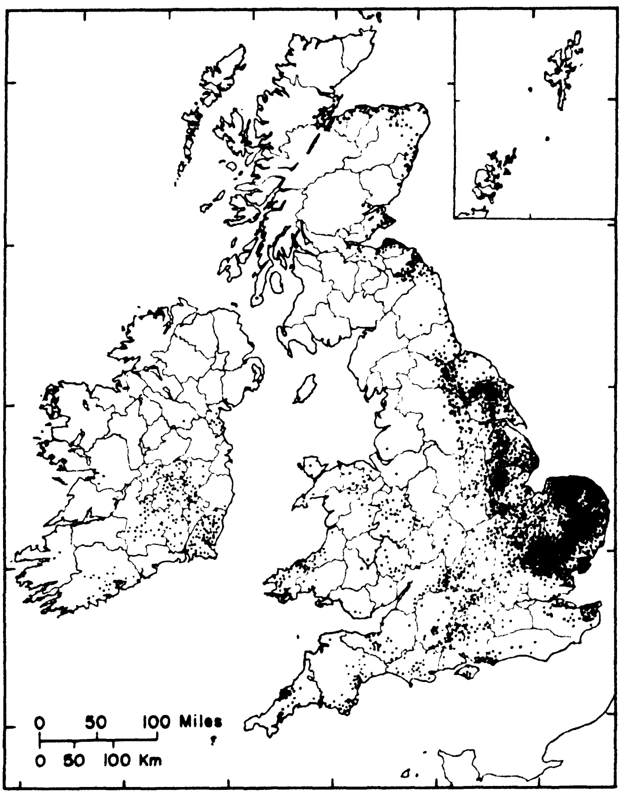



FIG. 89. Map showing the distribution of barley cultivation in the British Isles

Each dot represents 200 hectares (500 acres) in 1931 (Ireland, 1930). The reason for the choice of this year is the same as for wheat. The considerable cultivation now in Northern Ireland is a recent phenomenon.

This wartime expansion was in part made possible by selection of varieties suitable for local conditions. The majority of wheats grown in the British Isles were soft wheats which are not very suitable for breadmaking though they are of good quality. British strains of harder wheats, such as Yeoman and Holdfast, were developed and their cultivation extended. In the cooler northern counties, such as Durham and Northumberland, it was Swedish wheats which did well, in the dry east, Dutch varieties such as

Wilhelmina and Little Joss, and in parts of the south, wheats of French origin. The influence of climatic considerations on the choice of variety is unmistakable.

The bulk of British wheat is winter-sown and yields are higher than those for other cereals. For the ten years 1934–43, the yield in the United Kingdom averaged 2347.6 kilograms per hectare (18.7 cwt per acre) and by 1955–64, the yield in the United Kingdom was averaging 2603 kilograms per hectare (28.7 cwt per acre).[1] It is interesting to note that near the limits of wheat cultivation the yields are often high, probably because the area is small and more care is taken in choosing fields.

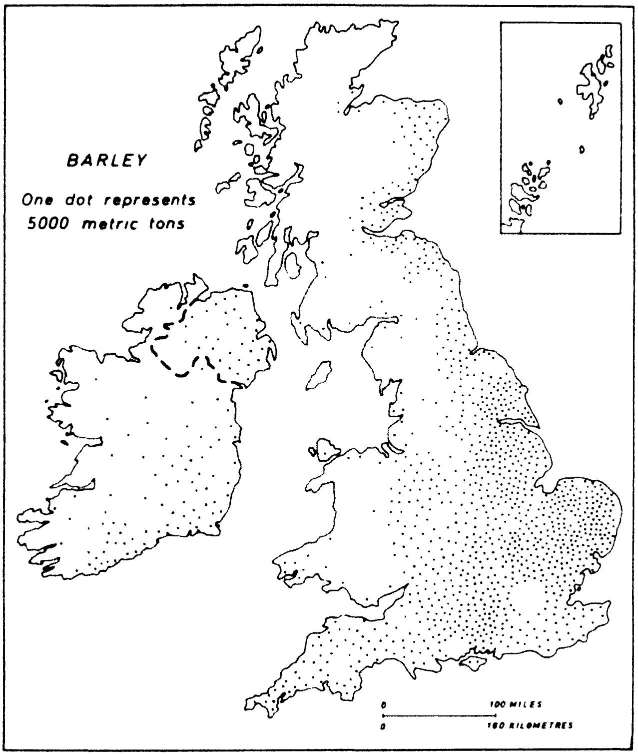



FIG. 90. Barley cultivation in the British Isles, 1966

## Barley

In the 1930s barley was the least important of the cereals occupying only about 400 000 hectares (a million acres), and was confined largely to eastern parts of Great Britain and to southeast Ireland (Fig. 89); the principal areas were in East Anglia and the main aim of farmers was to grow a crop of malting quality. Barley was, however, grown in more northern latitudes

1. Yields of all grain crops have risen appreciably since 1964, and in 1967 the UK figure was 4180 kilograms per hectare.

than wheat, possibly because it can take advantage of the longer summer days; in Scandinavia, barley will even ripen within the Arctic Circle. At the wartime peak there were 485 900 hectares (1.2 million acres) grown and, since the 1940s, there has been a dramatic increase in the importance of barley production. New short-strawed varieties out-yield oats and are well suited to mechanised corn growing and to heavy dressings of artificial fertilisers. Barley has thus become a profitable crop to grow and its lower susceptibility to the diseases which beset wheat and oats has enabled farmers to grow several crops in succession; it has also come to be accepted as a suitable feed for cattle. As a result, the area under barley has risen steadily, even though the amount of tillage has declined since the wartime peak; in 1966, 2.6 million hectares (6.5 million acres) were grown, or more than six times as much as in the 1930s. The crop has come to be grown much more widely and has gradually become the leading cereal crop in every area except northwest Scotland and western Ireland. Heavier applications of lime have probably helped this spread, as barley is particularly sensitive to soil acidity.

Most barley is spring sown and yields are consequently lower than those of wheat; in 1955–64 the average for the United Kingdom was 2251 kilograms per hectare (25.9 cwt per acre),[1] compared with 2134 kilograms per hectare (17.0 cwt per acre) in 1934–43. Most of the crop is now used for livestock feed, especially for pigs, and the demands for malting barley are much less important than formerly.

## Oats

Oats are much more widely grown in the British Isles than either wheat or barley, although the optimum conditions for the cultivation of oats closely resemble those for wheat. However, oats will grow and ripen under moister conditions and are more tolerant of high soil acidity; they can also, if necessary, be harvested green. Hence, of all the grain crops, oats are best suited to the climatic conditions of Ireland, the west of England, Wales and Scotland. Figure 91 records the distribution of the acreage under oats about 1931 and shows a similar concentration on the drier eastern side of both Ireland and Great Britain; but oats here compete with wheat and barley, and a comparison of the proportion of arable under oats would show that it occupied the lowest proportions in these eastern areas and the highest in western counties.

Since the Second World War, oats have been losing ground steadily to barley, partly because of the decline in the number of horses, to which oats were an important source of feed, and also because barley now out-yields oats; oats are also said to be less suitable for combining and much of the crop in western districts is still cut by reaper-binder. The total acreage in the United Kingdom has fallen from 1.5 million hectares (3.7 million acres)

1. In 1967 the UK yield had risen to 3780 kilograms per hectare.

in 1944 to 367 300 hectares (907 000 acres) in 1966 and that in the Irish Republic from 382 725 hectares (945 000 acres) to 98 400 hectares (243 000 acres). The decline has been widespread and barley has gradually replaced oats as the leading cereal in western counties, although oats still remain a relatively important crop in these areas of high rainfall. Oats are primarily grown for fodder and are consumed mainly on the farm on which they are grown; oat straw is also important for animal feed and is more highly regarded than either wheat or barley straw, much of which is now burnt after harvest.

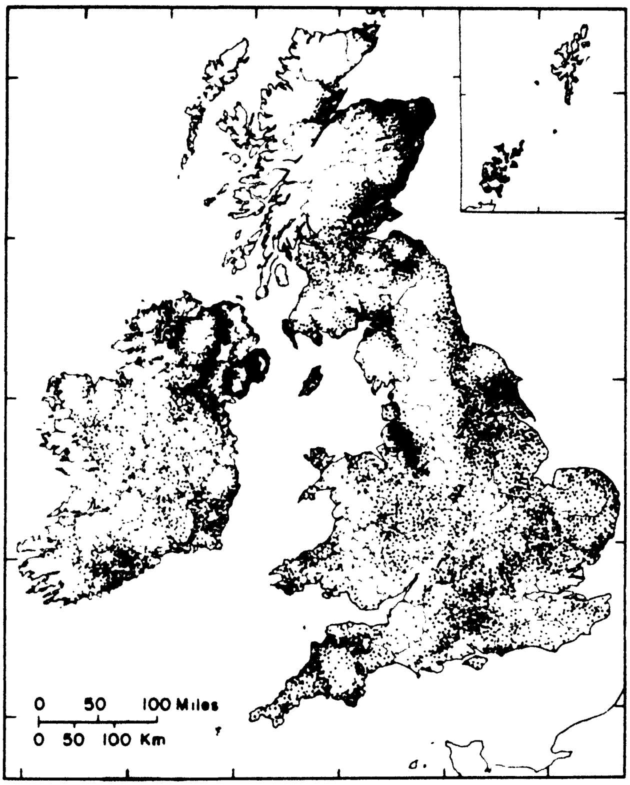



FIG. 91. Oats cultivation in the British Isles, 1931

Each dot represents 500 acres, the accompanying text explains the change that have taken place.

## Rye

Rye is often described as the poor relation of wheat and flourishes under similar conditions. However, it will tolerate far poorer soils and is thus widely grown on those derived from the glacial deposits of the north European Plain, which are the counterparts of those found in central Ireland and much of Scotland. Except as seed to produce green crops for sheep

feed, there is little demand for rye in the British Isles and the acreage grown was very small until the Second World War, when rye was mixed with wheat in the 'National Loaf'. In medieval Britain, rye was quite an important grain, but the British people lost, if they ever had, the taste for the rather sour though nutritious rye or black bread, which is familiar to all visitors to Germany and eastern Europe. The area in the United Kingdom jumped from 6800 hectares (17 000 acres) in 1938 to 52 200 hectares (129 000 acres) in 1943, in addition to that grown as green fodder, but by 1966 it was almost back to the 1939 area. Rye is grown mainly on areas of very light soil and some of the homegrown Irish rye is used in the distillation of rye whiskey.

### Beans and peas

Beans and peas, when allowed to ripen, were formerly included as corn crops, but it is now necessary to make a distinction between those grown for fodder and the vegetable crops. Beans are a heavy land crop and peas are better suited to light land. Both have declined greatly in popularity as fodder crops since the nineteenth century, although there has been some revival of interest in beans in recent years as farmers searched for alternative break crops.

### Mixed corn

The growing of mixed corn was of comparatively little importance in the British Isles in the 1930s except in a few counties such as Cornwall, where barley and oats (dredge) have long been grown together to provide fodder for livestock. Mixed corn can be cut green if necessary and the yield as grain is usually higher than that of either of the two grains grown separately. The prohibition on feeding wheat to livestock during the Second World War led to a considerable expansion in the acreage grown in the United Kingdom, which rose from 38 400 hectares (95 000 acres) in 1938 to 339 000 hectares (838 000 acres) in 1950. However, by 1966 it had fallen again to 29 500 hectares (73 000 acres).

### Potatoes

The distribution of potato cultivation in the British Isles provides one of the most interesting examples of the interaction of physical and economic factors. In the first place, potatoes are grown mainly for human consumption and there is not the important production for distillation of industrial alcohol that is found in continental Europe, especially Germany. Secondly, because of the character of the crop itself and its relatively low value per ton, potatoes enter little into international trade. Whereas in the British Isles as a whole most of the wheat which is required for human consumption is imported, nearly all the potatoes consumed are homegrown. Imports

consist mainly of early potatoes sold at high prices before the home crop is ready. Thirdly, potatoes have played rather different roles in the agricultural economy of Ireland and the crofting centres of northwest Scotland, and in the remainder of the British Isles. The peculiar suitability of potatoes to the humid soil and atmospheric conditions of Ireland were not appreciated until 150 years ago, prior to which, wheat and barley were the staple crops. It is not too much to say that the increased cultivation of potatoes

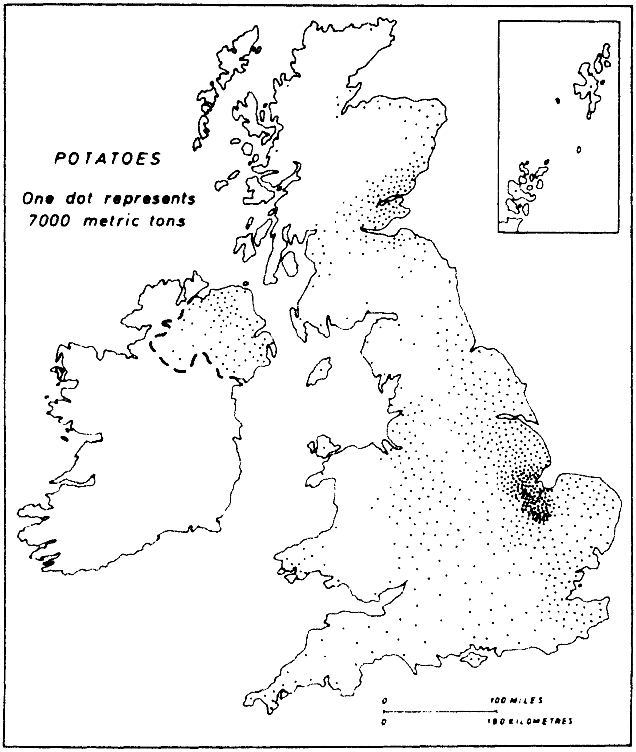



FIG. 92. Potato cultivation in the United Kingdom, 1966.
See also Fig 270.

made possible the large increase in population and perhaps actually occasioned the overpopulation of rural districts prior to the terrible famines of the 1840s. The area reached a maximum in 1859 when there were 373 400 hectares (923 000 acres) under potatoes in what is now the Irish Republic and in the decade 1847–56 potatoes occupied 19 per cent of the area devoted to crops. The potato is still widely grown as a food crop to supply local needs, irrespective of favourable soil or climatic conditions. The potato also plays a rather similar role in the Highlands and Islands of Scotland.

Elsewhere in Great Britain potatoes are grown mainly as a cash crop for urban markets, although surplus small potatoes are fed to stock and there

is an important trade in seed potatoes, which are grown in western and northern districts, notably in Scotland and western Ireland, where the risk of attack by aphids is low. In the Scottish Lowlands, potatoes are grown as a main crop, as an early crop or as seed; the deep loams of the eastern parts of the central Lowlands are particularly favourable for main-crop potatoes. The principal areas for the production of early potatoes in Scotland are situated in the southwest, especially along the coasts of Ayrshire. Close proximity to the sea permits sowing as early as February and the crop is lifted towards the end of June or early in July. Here the soil is light and sandy and has to be enriched by heavy manuring. Markets for these early potatoes of Ayrshire and for the later main crop are near at hand in the densely populated parts of the central Lowlands, but there is still a surplus available for sending southwards to England. In England and Wales also potatoes are widely grown for local consumption, but there is a remarkable concentration of cultivation in several areas.

Two factors are paramount. The first is the suitability of soil, deep, rich loams being the best, especially if free of stones which interfere with the free growth of tubers and handicap mechanical harvesting. Secondly, there must be ready accessibility to the main centres of consumption. The leading area of cultivation is to be found on the fine rich soils surrounding the Wash. In the Holland division of Lincolnshire and the Isle of Ely potatoes occupied nearly one-fifth of the total arable area. The development of potato growing here is a romance of the last hundred years. The silt lands were formerly cattle pastures, but perseverance with disease- and rot-resisting varieties of potatoes rewarded the effort of a local potato buyer and a local farmer. In neighbouring counties, especially on the Fen peats, the area under potatoes is also large. Potatoes from this area are destined very largely for the London market. The second great area is the Lancastrian Plain in Lancashire and Cheshire, where potatoes occupied respectively 12 and 10 per cent of the tillage acreage in 1966. Here potatoes are grown in the lowlands on the loamy soils derived from glacial material and supply the great industrial towns of Lancashire. On the fertile drift soils of the southern part of Durham there is an important production for the industrial northeast. Production in the West Riding and in Staffordshire again reflects the requirements of local industrial centres, while the London market encourages the growing of potatoes in Surrey and Kent. Special mention must be made of the movement of early potatoes from Cornwall, which are the first to be marketed in Great Britain; this is a matter of some importance because the earlier supplies are available the more valuable they are. Pembrokeshire has also become an important area for early potatoes in recent years, and still earlier supplies are available from the Channel Islands, where much of the arable land on the island of Jersey is devoted to potato cultivation.

The acreage under potatoes in the United Kingdom is now less than before the Second World War and is well below the wartime peak; how-

ever, owing to the steady improvement in yields, the volume of potato production is larger than prewar. In 1938 296 600 hectares (733 000 acres) were grown, giving a yield of 5 197 000 metric tons (5 115 000 long tons); by 1966 the figure had fallen to 267 000 hectares (660 000 acres), but the yield was 7 577 000 metric tons (7 458 000 long tons), compared with a wartime peak of respectively 574 900 hectares (1.42 million acres) and 9 980 000 metric tons (9 822 000 long tons). In Ireland the area under potatoes rose from 128 300 hectares (317 000 acres) in 1938 to 1939, to 173 200 hectares (428 000 acres) in 1941, but with only 68 000 hectares (168 000 acres) in 1966. In England especially, it should be noticed that, in addition to these quantities from farms, potatoes are widely grown in gardens and allotments.

### Turnips and swedes

The principal root crops grown for animal fodder in this country are turnips, swedes and mangolds; but a small proportion of the turnip crop is now grown for human consumption. In general, these root crops demand conditions similar to those required by potatoes, viz. deep stonefree soils, although this is less important with turnips that develop largely above ground and are fed to stock *in situ*. These root crops are largely grown as winter feed for sheep, and to a lesser extent for cattle, and it is often possible to correlate a reduction in the area, especially under turnips and swedes, with the reduced sheep population of the same areas. The introduction of turnips as winter feed for stock marked the turning point of British agriculture during the agricultural revolution, for stock previously slaughtered in the autumn could be kept throughout the winter on turnips stored in clamps. They do best under cool moist conditions, but yield is irregular and growth may be checked by early autumn frosts, especially in the north-east. In England and Wales there has been a steady decline in the area under turnips and swedes associated with the decline of sheep keeping on arable farms; in 1880 the crop occupied 11 per cent of the arable area in the country, by 1925 this proportion had fallen to 7½ per cent and it now stands at less than 1½ per cent. In Scotland and Ireland the crop remains more popular, but here, too, there has been a considerable decline.

### Mangolds

It is interesting to compare the distribution of mangolds, the other major root crop used for fodder, with that of turnips and swedes. The land under mangolds in Scotland is negligible; the summer is too short and the crop too susceptible to frost for there to be any extensive cultivation. On the other hand, in England, especially in the drier and warmer south, mangolds grow well and are definitely superior to turnips and swedes, for the yield is considerably higher. The average for the whole of England and Wales reached over 61 250 kilograms per hectare (24.5 tons per acre) in 1961–65,

and exceeded 75 000 kilograms per hectare (30 tons per acre) in the rich soil surrounding the Wash. Mangolds are also grown in southeast Ireland. Although the area under mangolds in England and Wales changed little between 1880 and 1930, with the general decrease in the area of arable land, this represented an increased proportion of the arable and illustrated the superiority of mangolds for cattle feed over other root crops. In recent years, however, high labour costs have led to the replacement of mangolds by other fodder crops and the acreage under mangolds has fallen by more than half.

### Sugar beet

Until after the First World War only a small acreage of sugar beet was grown, but in the 1920s the United Kingdom Government provided encouragement for its production in order to help arable farmers to grow an alternative cash crop. The acreage grown, some 180 500 hectares (446 000 acres) in 1966, is limited by agreement with other Commonwealth sugar producers and there is little doubt that more would be grown if this was permitted. Within this limitation, the distribution of sugar beet growing is governed by physical conditions and by the location of sugar beet factories, which have been erected in the main arable areas (see below, p. 220 and Fig. 99). Sugar beet is mainly confined to areas of deep, well-drained and stonefree soils in the drier and warmer parts of Great Britain, notably the Fenland and East Anglia; a small acreage is grown in Fife near the sugar beet factory at Cupar. In the Irish Republic beet is produced for a protected home market, and the 21 800 hectares (54 000 acres) grown in 1966 is sufficient for home needs. The crop is confined mainly to the eastern and southern counties, although a factory at Tuam has led to some planting in Galway; this factory is under-used and could support a larger acreage if markets were available, but there is little prospect of this.

### Kale

In recent years kale, especially marrow-stem kale used as winter feed for dairy cattle, has had an effect comparable with the spread of turnips during the Agricultural Revolution. Cattle are fed on the standing crop so that the cost of lifting and storage is avoided; the crop is nutritious and palatable. It is mainly grown in southern England.

### Miscellaneous fodder crops

The chief of these crops are rape, cabbage and other brassicas, vetches or tares, fodder mustard and lucerne. Rape is widely grown in western and northern districts as a fodder crop for sheep and as a pioneer crop. Vetches were formerly important as sheep feed, but only a small acreage is now grown. Lucerne is largely confined to neutral or alkaline soils in eastern

and southern England; its deep roots make it particularly suitable for areas where the water table lies some distance below the surface, as in the Breckland.

## Clover and rotation grasses

One of the major changes following the ploughing campaign of the Second World War was the reduction in the acreage under permanent grass. To a considerable extent this was counterbalanced by an increased acreage under clovers and sown grasses, which now occupy about one-third of the total area of arable land, although the proportion in the eastern counties, notably in the Fenland, is lower and that in the midland counties rather higher. In western counties of England and Wales the proportion is considerably greater; in Cornwall it exceeds 50 per cent, suggesting that land which is sown to grass in that county is left unploughed for at least three or four years. In Scotland, too, there is a marked difference in practice between the east and west. In the west, in Ayrshire for example, it is quite common practice to leave land under grass for ten to fifteen years and then to plough it for two; in the east sown grass for three years out of six was long the rule. The Scottish farmer improving rough hill grazing prefers to convert it to arable rather than to lay it down to permanent pasture. Clover and rotation grass may, of course, be grazed by livestock, but some is cut as green fodder and a considerable proportion is cut for hay. In Scotland rather over a quarter is so used, and in England and Wales normally a half, although the proportion is considerably higher in eastern counties. Hay made from sown grass is usually distinguished as seeds hay in contrast to meadow hay made from permanent grass. Special mention should be made of the timothy meadows which occupy considerable areas in central Scotland, particularly in northern Ayrshire and the adjoining parts of Lanarkshire and the Carse of Stirling; timothy grass is suited to heavy clay soil where the yield of other crops is uncertain. Much of the nutriment in grass is lost when it is made into hay and climatic conditions often make haymaking difficult; yet, despite these considerations, silage has not yet become very popular with farmers, although a subsidy on silos has encouraged the construction of large numbers. Dried grass, too, is handicapped by high drying costs.

## Flax

Flax can be grown either for fibre or for seed. In the United Kingdom, the growing of flax for fibre was once important in England, but it became almost entirely restricted to Northern Ireland until wartime needs brought back cultivation in many parts of England during the Second World War; it has now ceased to be of any importance anywhere in the United King-

dom, although Fig. 93 is retained as a reminder of its former importance. There has been a similar decline in the Irish Republic.

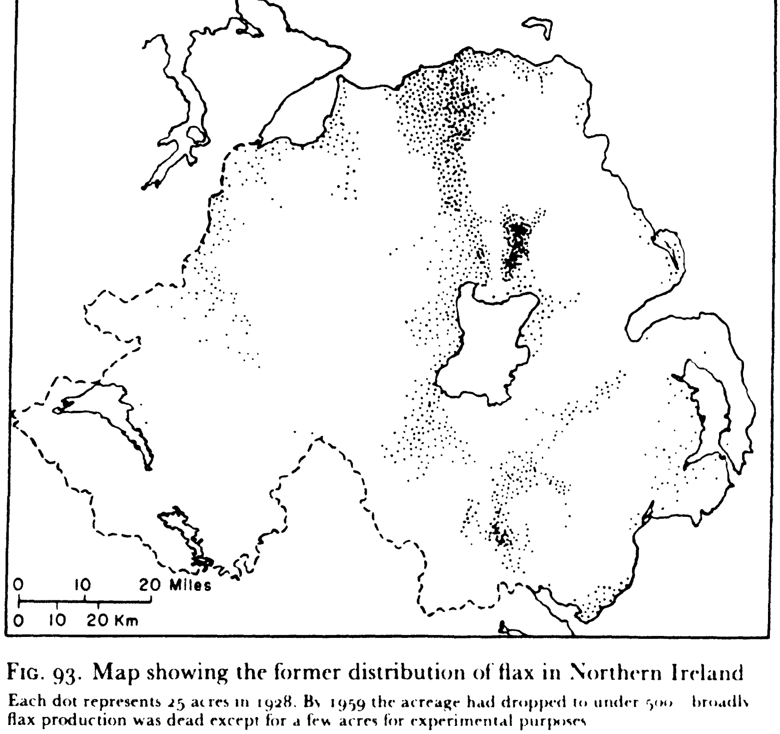



FIG. 93. Map showing the former distribution of flax in Northern Ireland
Each dot represents 25 acres in 1928. By 1959 the acreage had dropped to under 500 broadly flax production was dead except for a few acres for experimental purposes

## Hops

In recent years about 8000 hectares (20 000 acres) of hops have been grown, mainly in southern England. Considerably more than half is grown in Kent on the northern slopes of the Downs and in the Weald. The other centre of cultivation is the county of Hereford and the neighbouring parts of Worcestershire and Shropshire. Hops require deep, well-drained soils; they are demanding crops and require heavy manuring. In the past proximity to towns was thus advantageous. Formerly they were also noted for their heavy labour requirements and the harvest in Kent was undertaken by casual labour from east London. The harvesting of this crop is now largely mechanised and the former temporary hop-poles have now been replaced by semipermanent wiring, so that labour needs have been greatly reduced. The area of land planted is now controlled by the Hop Marketing Board, with which all producers must register. The marketing and processing of hops has now been largely centralised, but the oast-houses in which hops were dried and stored are still familiar features in southeastern England.

## Vegetables for human consumption

In 1939 the land under vegetables in the United Kingdom was nearly 118 000 hectares (291 000 acres); it rose to 204 000 hectares (504 000 acres) during the Second World War, largely owing to an expansion in the production of dried peas, but has since declined to 149 000 hectares (368 000 acres). It is difficult to analyse earlier trends because of changes in the

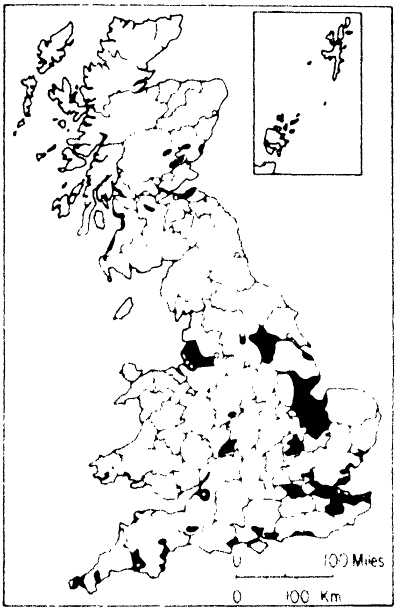



FIG. 94. The main market gardening and fruit farming districts of Great Britain

nature of statistics. These were originally confined to the acreage of market gardens, but it became so difficult to decide what to include in this category that the practice was abandoned and although land under the main vegetables continued to be recorded, there was no estimate of the total area. Nevertheless, it is clear that there has been a major change over the past century as vegetables have ceased to be the monopoly of market gardeners, and a large amount, admittedly of a relatively few common vegetables which lend themselves to field production, has come to be grown as a cash crop on arable farms. Vegetable growing is thus more widely dispersed than formerly; but it is still fairly localised and there are several highly distinctive areas which specialise in vegetable growing. Some of them also produce small and top fruit. The main areas for the intensive growing of fruit and vegetables are shown in Fig. 94.

Over thirty different kinds of vegetables are grown, each with a different distribution and its own requirements of soil and climate. A broad distinc-

tion can be made between the choice vegetables, which tend to be grown in small acreages, often by specialist vegetable growers, and the coarse vegetables, which are grown on a field scale by arable farmers. The former tend to be more demanding in their requirements and more localised, although the distribution of any particular category may owe a great deal to chance, to purely local circumstances, or to individual initiative; the latter are often more tolerant in respect of soil and climate. Such field crops as cabbages, which have low value in relation to weight and bulk, are grown widely throughout the arable areas and are favoured by those conditions which favour crop production in general; they also tend to be sold in nearby towns. For the areas of more specialised production, the nature of the soil is often important; deep, well-drained and stonefree soils which can be worked for long periods are well suited to most vegetables, but there is some tendency for soils of lighter texture, which warm up quickly and can be easily worked, to be preferred over heavy soils. Deficiencies of such light soils can more readily be made good by application of fertilisers and increasingly by irrigation, although a number of areas which depended on supplies of town manure have been handicapped in maintaining soil fertility by the great decline in the number of horses. Soil derived from the silts of the Fenlands or the brick-earths of the lower Thames Valley are particularly suitable, but in some areas, like the parts of the West Riding devoted to rhubarb growing, soils are largely manmade.

The climatic conditions suitable for tillage crops in general are also relevant to the growing of vegetables, but earliness is of much greater importance because of the high premiums which early crops of vegetables can command. Coastal areas are favoured, especially in southwest England, where winters are mild and crop growth begins early in the year. Most of the vegetables are grown in southern England, but it must not be too readily assumed that northern and western areas are unsuitable. In Scotland, it seems likely that dietary preferences play some part in explaining the relatively small acreage under vegetables.

Markets are thus also a major consideration in the distribution of vegetable growing. The development of road and rail transport has made proximity to urban markets less important than formerly, although there are still advantages in locations near towns, partly because produce may be fresher but also because supplies can more easily be provided at short notice. However, the complex nature of horticultural marketing and the role of central markets like Covent Garden make it dangerous to draw conclusions from the location of vegetable production in relation to towns and cities; and important areas, like the Fenland and mid-Bedfordshire, lie some distance from urban markets. A new kind of relationship to markets has also developed with the establishment of canneries and, more recently, of quick-freezing plant in the principal arable areas. Large acreages of peas, French beans and other crops are now grown near such plant, often on contract; for quick-freezing in particular, only a short time must elapse

between harvesting and processing, so that proximity is of great importance. As a result of the growing popularity of quick-frozen vegetables, the area devoted to such crops has risen sharply in recent years; there were 18 200 hectares (45 000 acres) of peas for quick-freezing in England in 1965, compared with 12 000 hectares (30 000 acres) in 1962, and although the land under vegetables in Ireland is small, there has been a similar expansion of vegetable growing for freezing and canning.

## Small fruit

Most of the small fruit produced in the United Kingdom is grown in three areas. The first of these includes Kent, especially the mixed soils of the fertile northern belt of the county, although small fruits are also grown in the neighbouring counties of Essex, Middlesex, Surrey and Sussex. This whole area accounts for a quarter of the total acreage. The second area, one-third of the total, lies around the Wash, includes parts of Norfolk, Cambridge, the Isle of Ely and the Holland division of Lincoln, and has an important centre at Wisbech. The third tract is the county of Worcester, together with the neighbouring parts of Gloucestershire and Herefordshire. In addition, Hampshire has important areas devoted mainly to strawberries, as have Devon, Cornwall and Somerset. Some 45 per cent of the area devoted to small fruit in England is under strawberries, and 33 per cent under blackcurrants. In Scotland the emphasis is on raspberries and strawberries and there is a similar concentration of small fruit growing, notably in the Carse of Gowrie, which has suitable soils, comparatively low rainfall and a generally southern aspect; this area specialises in raspberries and 75 per cent of the British crop is grown in the counties of Kincardine and Perth.

The great difficulty faced by growers of small fruit in the British Isles is the short ripening period in the summer; the markets are suddenly glutted for about a fortnight with each type of fruit and supplies are considerably in excess of demand. Jam-making, canning and deep-freezing play an important role in using this surplus.

## Orchards

Orchards are of negligible importance in Ireland, Scotland and Wales, although there are local concentrations south of Lough Neagh, in the Clyde Valley and in Monmouthshire; apart from the considerable number of orchard trees in gardens, there were 75 300 hectares (186 000 acres) of orchards in England in the 1966 agricultural census, of which 60 000 hectares (148 000 acres) were commercial orchards. Apples are the most important fruit, followed by plums, pears and cherries. Most of the fruit is grown in southern England and four groups of counties contain four-fifths of the orchards: Kent, where orchards occur on the high Weald, around Maidstone and in the fertile northern belt, leads with 25 500 hectares

(63 000 acres), mainly of apples and cherries (1966). Worcester, Hereford and Gloucester, with large acreages of plums and apples, come next with about 11 000 hectares (27 000 acres), followed by Devon and Somerset with 3600 hectares (9000 acres). These are old-established areas and a later development has occurred in Essex, Norfolk and Suffolk, which have 9300 hectares (23 000 acres); this is now the most rapidly developing area, with a high proportion of productive orchards under apples. The average yield of orchard fruit is far more variable than that of small fruit as the following table for two contrasting years shows; in any given orchard there is often an alternation of high and low yields per tree.

*Average yield per tree of orchard fruit in 1941 and 1947*

| DESCRIPTION | 1941 | | 1947 | |
|---|---|---|---|---|
| | kg | lb | kg | lb |
| Apples | | | | |
| Dessert and cooking | 8.8 | 19.5 | 38.7 | 85.4 |
| Cider | 15.5 | 34.2 | 48.8 | 107.8 |
| Pears | | | | |
| Dessert and cooking | 6.9 | 15.3 | 18.9 | 41.8 |
| Perry | 26.8 | 59.1 | 60.1 | 132.5 |
| Plums | 18.0 | 19.8 | 25.7 | 56.6 |
| Cherries | 6.7 | 15.7 | 32.3 | 71.3 |

It is difficult in a short space to summarise the essential climatic differences between these two years, but the following brief notes give some indication of the characteristics of the various months, the months March–May affect the blossoming and fruit setting, the months of July–September the ripening.

| *Months* | *1941* | *1947* |
|---|---|---|
| March | Cool; excess of E. winds | Very cold; snow |
| April | Dry and cold, excess of E. winds | Wet |
| May | Cold; severe frosts | Very warm |
| June | Dry | Warm |
| July | Warm | Warm with thunder |
| August | Cool and wet | Hot, dry and sunny |
| September | Dry and dull | Unusually warm |

Both climate and soils are important in the distribution of orchards, although, as with vegetables, the needs of the different crops vary considerably. Top fruit of good quality is likely only in the drier sunnier parts of the country. Frost is a particular hazard for the fruit grower and late spring frosts provide an additional disincentive to commercial fruit growing in northern areas; but frost is a widespread risk, which can be minimised only by careful siting, and it is a major cause of the variability of yield. Deep, well-drained soils are generally advantageous, though there are differences; cherries are particularly susceptible to poor drainage,

while plums do well on fairly heavy soils, provided they are not poorly drained. However, orchards are a long-term investment and, once planted, tend to persist even where they are not well sited.

Kent and Worcestershire are long-established areas which remain important, but orchards in western England are decreasing as old unproductive orchards are grubbed up. Since new planting is taking place mainly in eastern counties, there is a marked eastward shift of emphasis. Even the composition of the remaining orchards in the West Country is changing, for in addition to the grubbing up of entire orchards, it has been a practice for many years to plant dessert apples in gaps in orchards. The marketing of orchard fruit, especially dessert apples, is also undergoing change. Co-operatives and business groups are becoming more important and an increasing proportion of apples is stored in low-temperature gas stores, so that marketing of the home crop can be spread over a longer period.

## Flowers

Flowers and hardy nursery stock occupied some 13 750 hectares (34 000 acres) in the United Kingdom in 1966. The growing of bulbs for sale is largely confined to the Holland division of Lincolnshire and the bulb fields on the friable fertile soils derived from the Fen silts are now a considerable tourist attraction; the only other major area for bulbs is southern Cornwall, although there are interesting projects for developing bulb growing in northwest Scotland. Flowers for cutting are widely grown, but are found in two characteristic locations, around large towns and cities, especially London, which is the largest and wealthiest centre in the country; and in Cornwall and the Scilly Isles, where early crops can be produced, mainly between January and April. The growing of hardy nursery stock is also widespread and associated with large urban markets. It is especially prominent on the sandy soils of Surrey.

## Crops under glass

There were about 1620 hectares (4000 acres) of glasshouses in the United Kingdom in 1966. Like the distribution of flower-growing, that of glasshouses is both widely dispersed, with small amount of land in many localities, and highly localised in a few areas. The most important of these is the lower Lea valley, although it is less prominent than formerly; the growing of crops under glass developed here partly because of its proximity to the London market, but atmospheric pollution and urban expansion are now both considerable hazards. Other prominent areas are the south coast of England around Worthing, where average hours of sunshine are among the highest in the country; west Lancashire, especially near Blackpool, and around Hull; the Channel Isles, especially Jersey, also have a large area under glass. More than one crop a year can be grown in glasshouses and the crops differ throughout the year; tomatoes are the principal crop in

summer, accounting for nearly two-thirds of the land under glasshouse crops, but lettuces and flowers are the chief crops in winter. Apart from general considerations of proximity to markets, expressed more in premiums of freshness and for the reputation of 'local grown' produce than in lower costs and prices, the reasons for the location of glasshouse production are complex and often idiosyncratic. Physical factors play a minor part and, despite lower sunshine and higher heating costs, tomatoes from glasshouses in the Clyde valley are able to compete successfully with those grown by producers in other areas.

## Distribution of livestock in the British Isles

Livestock are the most important feature of British farming and most of the agricultural land is used for their support, whether as grazing on leys, permanent pasture or rough grazing, or for the production of fodder crops. Moreover, they have become gradually more important and, although the acreage of agricultural land in Great Britain has been declining steadily, numbers of most of the different classes of livestock, with the exception of horses and of older beef cattle and sheep, are higher than in the 1870s. The composition of the livestock population has changed considerably over the last hundred years, as numbers of cattle have risen steadily; the most marked changes have occurred in the last two decades, as the horse has ceased to be a major source of power on British farms and as intensive, large-scale production of pigs and poultry has increased in importance. The various branches of livestock farming have also tended to become more localised in different parts of the British Isles.

### Horses

It is difficult to get a correct view of the distribution and importance of the horse in the British Isles. There has been a steady decrease in the number of agricultural horses, especially in the post-Second World War period; numbers reached a peak just before the First World War, when there were just over 1.1 million in Great Britain and 394 000 in Ireland, but had fallen to 649 000 and 400 000 by 1939, and to 21 000 and 105 000 by 1965. The number of work-horses other than those on farms has also declined, though it is difficult to get actual statistics. On the other hand, horses and ponies for riding have probably increased in numbers in recent years. The breeding of horses as hunters, racehorses and others for pleasure purposes, including the production of bloodstock for export, is also important. In the British Isles as a whole, the location of breeding establishments is determined by the proximity to well-known race courses; thus, there are such centres of breeding as Epsom, Newmarket and Lambourn, where the existence of downland suitable for exercising horses has had an important influence. The United Kingdom is supplied to a considerable extent from

the well-known racehorse breeding industry in the Irish Republic, located mainly in the hinterland of Dublin. The decrease in number of agricultural horses is closely connected with the growth of mechanisation and detailed statistics are now published of agricultural machinery. In 1939 there were an estimated 56 000 tractors in Great Britain and only a small number in Ireland; by 1966 and 1965 respectively there were 496000 and 60 000. In general terms, every full-time farmer in the United Kingdom now uses at least one, and usually two, tractors and a full range of other machines.

## Cattle

In 1931 there were nearly 12 million cattle in the British Isles, 7 million in Great Britain and the remainder in Ireland. In 1966 there were 17.8 million, of which 11 million were in Great Britain. Yet, despite this growth, numbers in England and Wales did not at first keep pace with the rise in population, as the following table shows:

| YEARS | NOS. OF CATTLE PER 405 HA (1000 ACRES) OF LAND UNDER CULTIVATION | | | NOS. OF CATTLE PER 1000 OF POPULATION | | |
|---|---|---|---|---|---|---|
| | COWS AND HEIFERS IN MILK OR IN CALF | OTHER CATTLE | TOTAL | COWS AND HEIFERS IN MILK OR IN CALF | OTHER CATTLE | TOTAL |
| 1867 76 | 68 | 104 | 172 | 78 | 119 | 197 |
| 1877 86 | 70 | 109 | 179 | 74 | 115 | 188 |
| 1887 96 | 76 | 115 | 191 | 72 | 110 | 181 |
| 1897 1906 | 80 | 122 | 201 | 67 | 102 | 169 |
| 1907 14 (8 yrs) | 86 | 127 | 213 | 66 | 96 | 162 |
| 1915 24 | 95 | 129 | 224 | 69 | 94 | 163 |
| 1925 | 105 | 134 | 239 | 70 | 89 | |
| 1939 | 90 | 170 | 280 | | | |
| 1945 | 94 | 216 | 310 | 56 | 122 | 178 |
| 1950 | 104 | 237 | 300 | 63 | 149 | 212 |
| 1960 | 149 | 230 | 349 | 94 | 132 | 226 |
| 1966 | 157 | 211 | 347 | 79 | 106 | 186 |

There is a broad distinction between dairy cattle and beef cattle, although, as will be seen later, many of the animals slaughtered for beef are derived from dairy herds. About a third of the total cattle are cows and heifers and, in the United Kingdom, where it is possible to distinguish those being kept mainly for dairy herd from those rearing calves for beef, dairy cows outnumber those rearing calves for beef by four to one. Beef animals are more important in Ireland and Scotland.

## Dairy cattle

The number of dairy cattle in the British Isles has been rising steadily since statistics were first collected and dairying is now the most important single

enterprise on farms in the United Kingdom; in 1866–70 there were 2.1 million cows and heifers in Great Britain and 1.5 million in Ireland, compared with 4.6 million and 2.1 million respectively in 1966, although these numbers also include animals in beef-rearing herds. Dairy cattle are widely distributed throughout the British Isles, but they are most common in the western lowlands of Great Britain, notably in Cheshire, Somerset, Carmarthen and southwest Scotland, and in southwest Ireland. The most important among the many reasons for this distribution are the physical requirements of dairy cattle, characteristics of the markets for milk, and the structure of farming in the British Isles.

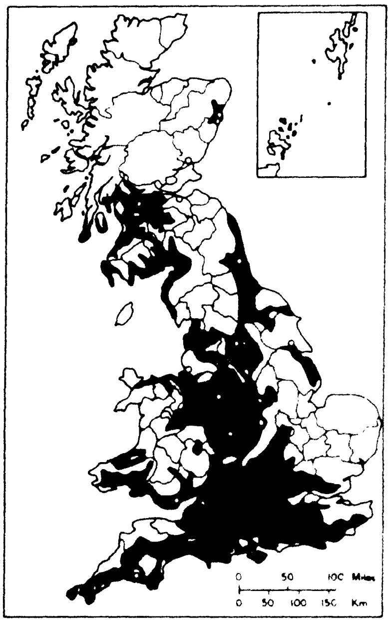



Fig. 95. Map showing the main dairy-farming areas in Great Britain

Although the different breeds vary in their requirements, dairy cattle are more sensitive to exposure and low temperature than other grazing livestock. The optimum temperature for milk production is said to be about 10°C (50°F) and, while adverse weather can be evaded by housing dairy cattle in winter months (and there is a south–north gradient of increasing length of housing), the greatest densities are found in the southern half of the British Isles, especially in the milder climates of the west. Feed requirements also contribute to this distribution, for dairy cattle must be well fed if they are to produce high yields of milk and, while they can be and are fed on arable crops and purchased concentrates, grazing provides the cheapest feed and dairy cattle are most prominent in those areas where there is an abundant pasture of good quality and a long growing season.

The better grasslands of the west and southwest thus provide the optimum physical conditions for dairy cattle, but the distribution of such animals is also affected by the outlets for milk. Milk has two quite different markets, for it may either be made into butter, cheese or other milk products, or sold for consumption as liquid milk. Since milk is perishable and loses both weight and bulk in the manufacture of products which can be more easily transported and stored than liquid milk, location theory indicates that dairy cattle supplying milk for liquid consumption will be kept near towns and that cattle producing milk for manufacture, which fetches a lower price, will be found in remoter areas where physical conditions are suitable for dairying. Such a relationship was true of Great Britain a hundred years ago, for most milk for liquid consumption came from stall-fed cattle in town dairies or from farms on the outskirts of towns, while dairy cattle kept in areas like Cheshire and Somerset supplied milk for making butter and cheese; but this situation has been transformed by the growth of the urban milk market, by improvements in the transport of milk and by the creation of producer-controlled marketing boards, so that more than two-thirds of the milk produced in Great Britain is now sold for liquid consumption and only that which is surplus to the requirements of the liquid milk market is manufactured; for a safety margin is necessary to ensure that supplies are always available.

Improvements first in rail transport and then in road transport have gradually extended the distance over which milk can be transported without deteriorating until virtually all lowland areas of Great Britain are now capable of supplying urban markets with milk; an increasing proportion of milk is now being collected by bulk tankers direct from farms. At the same time, the demand for liquid milk was expanding with the rapid growth of the urban population and a general rise in the standard of living. The keeping of dairy cattle to supply milk was becoming increasingly attractive to farmers in many parts of Great Britain who had been hard hit by competition from imported produce; for, unlike milk products, liquid milk enjoyed virtually complete natural protection against imports. These trends towards a wider distribution of milk production were accentuated by the creation of milk marketing boards in 1933. These, by pooling the returns from sales of liquid and manufacturing milk, and by the pricing policies they adopted, minimised (for the individual farmer at least) the importance of location. The farmer received the same price for his milk irrespective of its destination and did not pay the full cost of its transport to markets.

The assured market and a regular monthly income which the marketing boards provided for milk producers made the keeping of dairy cattle particularly attractive to those with small farms. Dairying is also an intensive system of farming, requiring large inputs of labour, and hence is suitable for occupiers of small holdings who can increase the effective land of their farms by purchasing feed. Such farms are found in many parts of Great Britain, but they are particularly numerous in western counties and, where

physical conditions made milk production possible, dairying was often adopted in such areas in place of more extensive systems like stock rearing.

In the last decade, this tendency towards a wider distribution of dairy cattle has been reversed. Rising yields have led to surpluses of liquid milk and dairying has become less profitable. Many farmers, especially in eastern counties where other enterprises are possible, have therefore ceased to keep dairy cattle and, as a result, the proportion of the national dairy herd in western counties is rising.

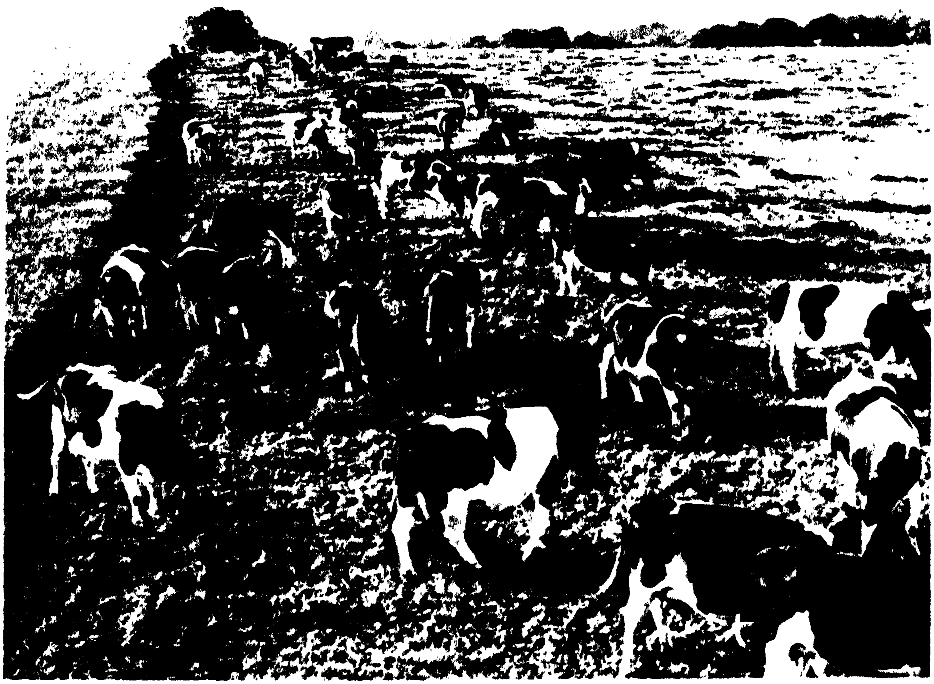


PLATE 5. A Friesian dairy herd in Kent: strip grazing controlled by electric fences

Despite these developments some differences between areas of Great Britain producing milk for liquid consumption and those producing milk for manufacture survive, and in Ireland, where the urban milk market is much smaller, a clearcut distinction remains. Thus, much of the milk surplus to urban requirements in Great Britain is produced cheaply on grass in summer in areas like southwest England, Wales and Scotland and a higher proportion of milk is manufactured in these areas. In Ireland the keeping of dairy cattle to supply milk to urban markets is largely confined to the area around Dublin and other large towns, while milk produced in the main dairying areas is sent to creameries for manufacture.

While the Friesian is the most important single breed of dairy cattle in

the British Isles, there are considerable regional differences in breed structure of dairy herds. The Friesian predominates throughout England and Wales, but the Ayrshire and Dairy Shorthorn account for most of the remainder. The Shorthorn is overwhelmingly the most important breed in Ireland and the Ayrshire, a relatively hardy animal, occupies a similar position of dominance in Scotland. Among the minor breeds, Channel Island cattle (Guernsey and Jersey) are important only in southern England. The Friesian has been increasing in popularity because of its high yields and because surplus calves are suitable for rearing and fattening ing as beef animals.

Dairy cattle differ from other grazing livestock in that there is relatively little seasonal movement of animals between different parts of the country, apart from the sales of surplus calves and cows to be fattened for beef; most dairy herds are self-contained and breed their own replacements. However, there are regional differences in the seasonal pattern of calving and of milk production, reflecting differences in outlets for milk and in the availability of feed. In western counties of Great Britain, where milk can be produced cheaply on grass, there is a higher percentage of spring calving and more milk is produced in summer, while in eastern counties, where fodder from arable crops is abundant and there are advantages in concentrating on more profitable winter milk production, the balance is more even.

## Beef cattle

Beef cattle have also increased in importance, especially in the post-Second World War period when the British Government has been encouraging the production of beef. However, it has never been easy to draw a sharp line between dairy cattle and beef cattle, and it has become more difficult with the increasing use of artificial insemination and with the expansion of dairy farming; thus, some two-thirds of the young animals reared for beef are the offspring of dairy cows and about a quarter of the cattle slaughtered for beef are old cows and bulls, many of which have come from dairy herds. In Ireland, too, most beef cattle originate on dairy farms. However, changes in numbers of cattle other than cows and heifers do give some indication of the expansion of beef production, although this category includes dairy herd replacements as well as cattle intended for slaughter. In 1866–70 such other cattle numbered 3.1 million in Great Britain and 2.2 million in Ireland, compared with 6.4 million and 4.7 million respectively in 1966. These figures conceal quite important differences in the composition of the national herd, for whereas cattle of two years and over have been declining in numbers in recent years, those between one and two years old have been increasing rapidly, reflecting a fall in the average age of slaughter.

Beef cattle are relatively more important in Ireland and Scotland, but it is necessary to consider the British Isles as a whole in examining their distribution because of the large movements of dairy cattle from Ireland to

Great Britain. Figure 96 shows that beef cattle are most numerous in the Irish lowlands, southwest England, the Midlands and northeast Scotland; there are fewest beef cattle in the uplands. However, this map is somewhat misleading in that it includes all stages from breeding to fattening, each of which exhibits a somewhat different regional pattern. Cattle intended for slaughter as beef may be born of dairy cows on farms in many parts of the country; they may also be born to cows of beef breeds, like Herefords and Aberdeen Angus, either on lowland farms or on farms on the margins of the uplands. Surplus calves on dairy farms are likely to be sold shortly after birth, but others will probably spend some time on the farm on which they are born.

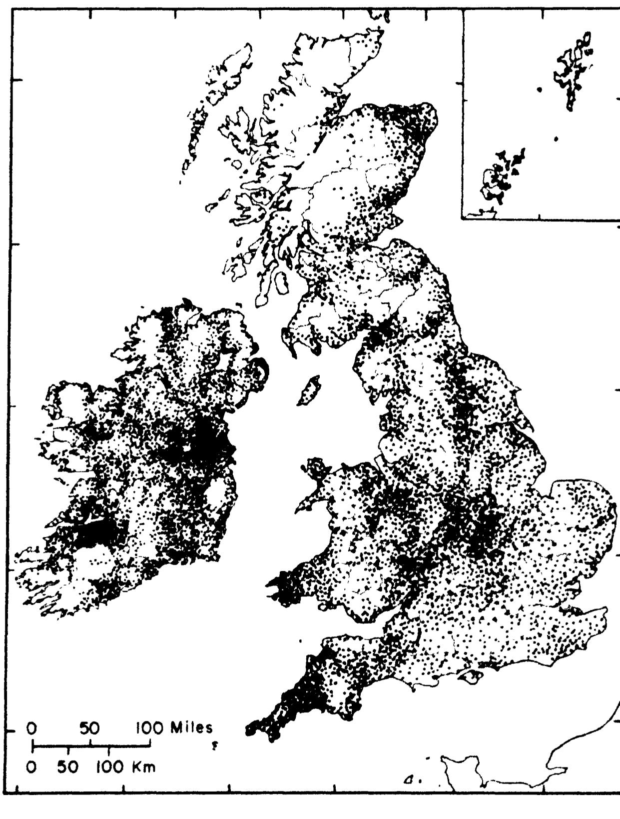



FIG. 96. Map showing the distribution of beef-cattle in the British Isles

Each dot represents 1000 animals.

The breeding and rearing of young beef cattle is especially characteristic of family farms on the upland margins in areas like the Welsh borderlands and northeast Scotland, for beef cattle are less demanding than dairy cattle in the early stages of their lives and can use the rough grazings and poor

pastures; about half the cows in beef herds in the United Kingdom are found in such areas and qualify for the hill cow subsidy. Older animals may be found on farms in most parts of the British Isles, either being kept as store animals for a limited period to use surplus grazing or fodder, or being reared and fattened. In general, beef cattle tend to move eastwards to other farms in the lowlands as they get older, although the detailed pattern of movement is highly complex. Furthermore, over half a million animals are exported from Ireland to Great Britain, either for slaughter or to be fattened on farms in eastern counties. Beef cattle may be fattened on farms in many parts of the lowlands, either on grass in the summer months or on arable crop residues during the winter. However, certain areas have tended to specialise in the summer feeding of cattle, notably the plains of Meath in Ireland and the east Midlands in England, where there are pastures of high quality. Fattening in yards in winter has long been characteristic of arable districts in eastern counties in England and Scotland, and such cattle are often kept as much for the manure they provide as for the contribution they make to farm income. In recent years there has been increasing interest in the intensive rearing and fattening of beef cattle on arable farms, with animals being slaughtered at under fifteen months; in 1964 between 5 and 10 per cent of beef supplies in the United Kingdom were thought to have been produced in this way.

## Sheep

The British Isles have long been famous for their sheep. Not only was wool a staple product and export in the Middle Ages, but at a later stage British sheep became well known for their meat. Most of the British breeds are heavy animals, producing good, well-flavoured meat, and at the same time having a heavy fleece of excellent quality wool. The large sheep populations of the great grassland countries of the southern hemisphere, such as Argentina, Uruguay, South Africa and New Zealand, are very largely of British origin. The only rival of the British breeds is the Merino, a wool-producing sheep suitable for arid conditions. There are normally as many sheep in the British Isles as in the whole of New Zealand and between a quarter and a third of the total in the Australian continent. Numbers of sheep, though large, have fluctuated more markedly than those of cattle and their distribution has also changed more markedly. In 1866–70 there were 27.9 million in Great Britain and 4.6 in Ireland, compared with 28.9 and 5.7 million respectively in 1966; there has been a rapid increase since the Second World War when numbers were deliberately run down and there were only 19.4 million in Great Britain in 1944. As Fig. 97 shows, sheep are to be found mainly on and around the uplands of the north and west, especially the Southern Uplands in Scotland, the northern Pennines and the Lake District, and Wales; the principal lowland areas where sheep are prominent are the east Midlands, where both sheep and cattle are

fattened, and Romney Marsh, which has the highest density of sheep anywhere in the British Isles. Although numbers in Ireland are much smaller, sheep are also found mainly on and around the uplands. A century ago sheep were more widely distributed and there were many more in the lowlands, especially in the arable areas of eastern England, where sheep were

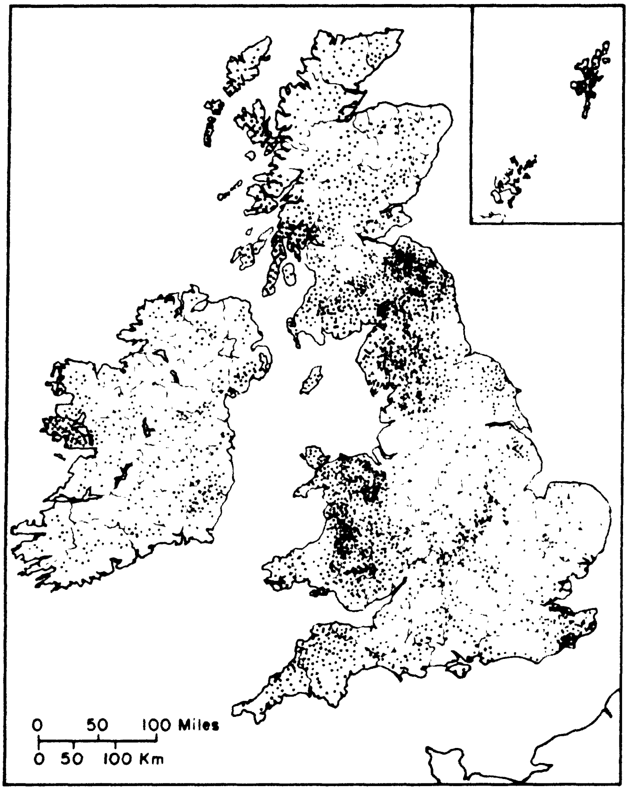



FIG. 97. Map showing the distribution of sheep in the British Isles

Each dot represents 10 000 animals. Total in the United Kingdom 29 million in 1961

folded on arable land; increasing labour costs have tended to exclude sheep from arable farms, except as scavengers of crop residues, and sheep compete with dairy cattle for available grazing on lowland pastures. This trend towards the concentration of sheep in the uplands has become more marked since the Second World War as numbers have increased in western counties of Great Britain and declined in the east, although in parts of the uplands afforestation has reduced the acreage of hill pasture and numbers have either fallen or increased at a much lower rate than elsewhere. But there have also been changes in the composition of the sheep flocks; the decline in the demand for mutton has led to the virtual disappearance of wether

sheep and most flocks now consist mainly of breeding ewes, ewe replacements and lambs.

Sheep are a source of both wool and meat, mostly lamb, but only in the uplands is wool an important source of farm income; such wool is not of the best quality and is mainly used for carpet-making. The reasons for the

PLATE 6. Dorset horn lambs folded on swedes and kale

present distribution are in part economic and in part the physical requirements of sheep. It is clearly fallacious to claim that sheep cannot thrive under damp conditions, for they are most numerous in the wetter areas of the British Isles; the actual rainfall is not so important, provided that drainage is good. The hardier breeds of sheep are better able to withstand exposure and cold than other livestock; they are also less demanding in their requirements of feed, water, housing and attention than cattle and are able to graze the poorest upland pastures which would otherwise go unused. Their distribution in the uplands is in part an index of the quality of grazing, with the lowest densities in the Scottish Highlands where the environmental conditions are most extreme and the carrying capacity is very low. The extent of common land, which tends to be overstocked, and the size of the predominant breeds are also factors which need to be taken into account in explaining differences in density of sheep. Conditions in the

uplands are far from ideal for sheep and numbers tend to fluctuate greatly in response to weather conditions; the sheep population of Great Britain was reduced by over 3.5 million (about one-sixth) between 1946 and 1947 because of the severe weather of the intervening winter. Sheep are thus numerous in the uplands because no other enterprise is possible on much of the land grazed by them; by contrast, sheep tend to be excluded from lowland areas because the keeping of sheep is less profitable than other enterprises.

Like beef cattle, sheep tend to be reared and fattened in farms in different parts of the country and there is also a marked stratification of sheep farming with altitude, in which the degree of dependence on sheep declines with height above sea-level and farms at higher altitude supply those lower down with stock for fattening. On the poorest uplands, where sheep are often the only enterprise, ewes of hardy breeds graze for several seasons, bearing a crop of lambs each spring. The ram lambs are generally sold to occupiers of lowland farms where they are fattened, although there is an increasing tendency for upland farms to fatten lambs where this is possible; many of the female lambs are required for flock replacements and these are often sent away during their first winter to the kindlier conditions of lowland farms. Mortality rates are much higher than on lowland farms and those ewes which survive the severe conditions for several seasons are usually sold as cast ewes to lowland farmers, who may cross them with a ram of lowland breed to produce a flock of half-bred lambs for fattening. Offspring of these crosses may similarly be crossed with rams of arable breeds. Pure breeds of hill sheep may also be kept on upland farms which specialise in cattle rearing and lowland farms may also support purebred flocks whose role is in part to provide rams for crossing with ewes of upland breeds. Thus, in general, this stratification of sheep farming results in a progressive mixing of breeds at lower altitudes, a decreasing importance of sheep in the farm economy and a shift of emphasis from breeding to fattening. It is claimed that such an arrangement represents a more efficient use of resources, in that the poorer quality land is used for less profitable breeding and the better for fattening, and that the role of the uplands as a reservoir of breeding stock produces animals which combine the hardiness of the upland breeds with the rapid growth and larger size of the lowland breeds.

This account shows that crossbreeding plays an important part in sheep farming and that no simple picture of the distribution of sheep breeds is possible. There are more than thirty different breeds, many of them adapted to local environments. In Scotland two breeds predominate, the Blackface and the Cheviot, the former mainly on the heather-covered hills, the latter especially on the grass moors of southern Scotland, although a special strain, the North Country Cheviot, is found in Caithness. In northern England, the distinctive Herdwick is characteristic of the Lake District, and the Teesdale, Swaledale and Wensleydale in the northern Pennines; while in Wales the small Welsh mountain breed is common. Characteristic breeds

of the lowlands include both grass sheep like the Leicester, arable sheep like the Suffolk, and the Down breeds. In Romney Marsh and the rest of Kent, most sheep are of the Romney Marsh breed. There are, of course, many permutations of upland and lowland breeds, resulting in a great variety of first and second crosses. In Ireland the Cheviot is by far the most important breed, followed by Down breeds.

This progressive concentration of the sheep population in upland counties has led to considerable investigations of the possibility of improving upland pastures, which provide sufficient food for growth only in the short summer period. Pioneer work in this respect was done by the late Sir George Stapledon at the Welsh Plant Breeding Station at Aberystwyth. He pointed out that, after the Napoleonic Wars, isolated but well chosen areas were ploughed for oats on the Welsh hills up to 450 or even 500 metres (1500 or 1700 feet), and that these areas can still be distinguished by the better pasture they provide. It is clear from these patches, with their comparative abundance of *Agrostis* rather than moorland grasses, and the occurrence of white clover and such weeds of cultivation as hawksweed, that the surrounding areas of pasture might in any case be much better than they are. When he made his survey of the hill lands of Wales in the 1930s Stapledon found something like 800 000 hectares (2 million acres) of rough hill pastures, about half mainly of grass, of which he considered half favourable from the point of view of aspect and other considerations for improvement. The very wet areas of cotton grass, sphagnum and other types of bog would be expensive to drain, but there remained three types of grass pasture suitable for consideration: (*a*) *Molinia* or flying-bent pasture; (*b*) *Nardus* or mat grass pasture; (*c*) bent-fescue (*Agrostis-Festuca*) pasture. The natural defects of these pastures are that *Molinia* is deciduous and is used by sheep for about one month; *Nardus* is unpalatable to sheep and, whilst the bent and fescue are palatable, they are of low feeding value, particularly in that they lack lime. Further disadvantages are the lack of leguminous plants such as white clover, and of herbs, such as daisies, which have an excellent feeding value.

The need is to introduce wild white clover, and more palatable grasses with a longer growing season. Even by the simple process of cutting, grazing hard and then manuring, the bent and fescue, i.e. the better grasses, are increased in numbers; large areas can also be improved by surface cultivation and reseeding. Stapledon claimed that 10–15 per cent of the land of the sheep walks might be improved and, by the proper alignment of fences, this improved land could be used in such a way that each of the major sheep walks had a proportion of it. He further suggested that much also might be done by the planting of trees as shelter belts, so that it would be possible for sheep to be kept on the fells or hill pastures throughout the year. Heather moorlands can be improved in the same way, by the simple process of burning, since young heather itself has an important nutritive value for sheep feeding. Stapledon considered it would pay also to keep limited

numbers of cattle on the hill pastures, not because the cattle themselves could be expected to pay, but they would gradually benefit the ground by their manure. In the event not much of the uplands has been improved, despite the availability of grants towards the cost; hill sheep farmers have generally lacked the resources necessary, even with grant aid.

## Pigs

Pigs have also increased greatly in importance over the past hundred years. There were 2.5 million in Great Britain in 1866 and 1.2 million in Ireland, compared with 6.3 million and 2.1 million respectively in 1966. Numbers fluctuate considerably in accordance with the pig cycle (which has a periodicity of some four years) and partly in response to government policy, as during the Second World War, when numbers fell by more than half. Pigs, which are sensitive to cold and exposure, are confined to the lowlands, but their distribution is very patchy and there is none of the regionalisation of breeding and fattening that characterises the keeping of beef cattle and sheep, although there is some specialisation of function between those who rear and those who fatten pigs. Pigs are often associated with small holdings and a tenth of those in the United Kingdom may escape enumeration because they are on holdings of 0.4 hectare (1 acre) or less (the minimum size recorded in the annual agricultural census).

Pigs can be fed on waste human food and there are often considerable numbers around large towns and cities, as in Greater London. There is also an association between pig keeping and arable farming, especially the growing of barley and potatoes, but pig keeping was sometimes established for reasons which now have little validity, as with the association between pigs and farmhouse cheesemaking in Cheshire. In the main, size of holding seems a more important consideration and most pigs are found on small holdings; in Ireland more than two-thirds are on holdings of under 40 hectares (about 100 acres). Large Whites predominate in both countries, with Landrace as the second breed.

## Poultry

It is not easy to obtain accurate estimates of the number of poultry or to make comparisons over time. In the United Kingdom numbers of poultry have been regularly recorded in the agricultural census only since 1926, but many farmers do not know accurately how many they have and possibly a quarter of all poultry escape enumeration because they are not on agricultural holdings of over 0.4 hectare (one acre). Whatever the truth about earlier changes, numbers in the United Kingdom have been rising rapidly since the Second World War, when they were drastically reduced as part of the Government's programme for home food production. There were 119 million in 1966, compared with 55 million in 1944 and 72 million in 1938. Poultry keeping in the Irish Republic has been adversely affected

by these developments in the United Kingdom, particularly by the low price of eggs, and there were only 11 million in 1966, compared with 21 million in 1950. Like pigs, poultry are largely confined to the lowlands and require little land. The largest concentration is in Lancashire, which had 8 per cent of the poultry in Great Britain in 1966, although the dominance is less marked than formerly; other important areas are in the east Midlands, East Anglia, and the counties around London. In Ireland poultry are most numerous in Connacht and Ulster. The great majority of poultry in both countries are fowls; small numbers of other kinds of poultry are found in many lowland areas but there are important concentrations of ducks and turkeys in East Anglia.

In the past poultry have shown an even more marked association with small holdings than have pigs, and on many larger farms the poultry flock was the perquisite of the farmer's wife. In recent years, however, there have been major changes as a result of industrialised methods of poultry farming which is increasingly being undertaken by specialists on a large scale. This change has been very rapid; for example, in England and Wales in the 1950s the numbers of fowl kept free range fell from over nine-tenths to under a third. A rising proportion of egg-laying fowl are kept in large units under intensive systems requiring little land, but much capital for buildings, while there has been a rapid increase in the number of broilers (intensively reared table birds), which numbered 31 million in June 1966. Similar developments, although on a much smaller scale, have been taking place in Ireland and Scotland. Intensive rearing of ducks and turkeys on a large scale is also being practised, notably in East Anglia. Location is not a major consideration and little land is required; the distribution of such holdings is thus very patchy.

## Number and size of agricultural holdings

This discussion of the distribution of the different kinds of crops and livestock has shown that farm size is an important factor. Unfortunately there is little information on farms as such, although the number of farmers is enumerated in the population censuses. The data for the agricultural censuses are collected by holdings, many of which are not farms in the ordinary sense. In the United Kingdom a holding is a unit of more than 0.4 hectare (one acre) of agricultural land and many smaller holdings are accommodation fields, grounds of large establishments and the like which serve some agricultural purpose. Any concept of an average farm obtained by dividing the acreage of farmland by the number of holdings must clearly be treated with considerable reserve. In 1966 there were 374 000 holdings in Great Britain, of which 73 000 were under 2 hectares (five acres) and occupied less than 0.5 per cent of the agricultural land, and nearly 12 000 were of 200 hectares (500 acres) and over and occupied 41 per cent. In Northern Ireland there were 66 000 holdings in 1963, but only sixteen were

of 200 hectares (500 acres) and over (as measured, not by total area but by the land under crops and grass), occupying 0.5 per cent of the area in crops and grass. In the Irish Republic there were 283 000 holdings in 1965, 2605 of them exceeding 120 hectares (300 acres) in size.

Although the evidence is ambiguous, there is little doubt that farms are tending to increase in size; and the great expansion in mechanised farming has provided an incentive to enlarge holdings, especially in the eastern counties of England where the proportion of land in holdings of 120 hectares (300 acres) and over rose by more than 15 per cent between 1939 and 1965.

In interpreting the regional distribution of holdings, it should be noted that much of the information about holdings relates only to improved land, i.e. rough grazings are excluded. This does not matter in most lowland areas, but it can give quite misleading impressions in the uplands; for example, a hill sheep farm of 400 hectares (a thousand acres) or more will include little improved land. Even where rough grazing is taken into account, it must be remembered that there are about 607 000 hectares (1.5 million acres) of common rough grazings in England and Wales, about 490 000 hectares (1.25 million acres) of common pasture in the crofting counties of northwest Scotland, and an unknown quantity in Ireland; such land in effect enlarges the size of holding of those who have rights to use such common grazings.

Although a wide range of holdings of different sizes occurs in most areas, there are quite important regional tendencies. Large holdings are associated particularly with areas of mechanised arable farming, especially cereal-growing on the chalk lands of southern and eastern England. Large holdings of a very different kind are found on the rough grazings of the uplands, with the largest holdings on the poorest land, as in north Scotland. Small holdings are similarly characteristic of two quite different situations: the areas of intensive horticulture, like the Fenland and Worcestershire; and poor grazing land on the margins of the uplands and on the west coast of Ireland and northwest Scotland and the islands. Many of these holdings on poor land are too small to provide an acceptable standard of living and their occupiers often have other employment. Both the crofting districts of northwest Scotland and the congested district of western Ireland present problems in this respect.

Size of holding provides some indication of regional difference in size of farm, but, as has been shown, size alone is clearly unsatisfactory; for a small holding associated with an intensive kind of farming may provide full-time employment, while a larger holding devoted to extensive grazing cannot. Various attempts have been made to improve the kind of information available. Before the First World War occupiers of holdings in England and Wales were asked to say whether they farmed mainly for business or not; only 5 per cent said they did not, although this proportion reached 19 per cent in Surrey. During the Second World War, a National Farm Survey of England and Wales, confined to holdings of 2 hectares (5 acres) and over,

showed that 74 per cent were full-time farmers, 11 per cent part-time farmers, and 15 per cent spare-time and hobby farmers. This last category was particularly common around large cities and in areas like Cardiganshire where there had formerly been an association between mining and farming. Spare-time and hobby farming appears to have increased in importance since this survey, especially in the area around the London conurbation.

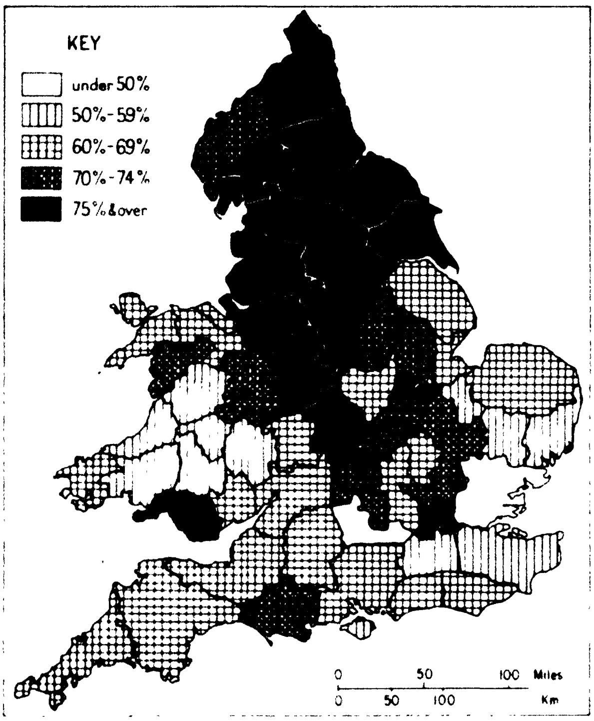



FIG. 98. Proportion of tenant farmers in England and Wales

Although tenant farmers are most numerous where there are large estates in the north and fewest in the home counties with their numerous smallholdings this map reflects local custom more than geography

From *National Farm Survey of England and Wales 1941–43* by permission of the Controller of H.M. Stationery Office

More recently, agricultural economists in the United Kingdom have extended this approach by analysing holdings by size of business rather than by area, using standard labour requirements as a basis for comparison. Those holdings which require fewer than the standard labour requirements for one man (275 standard man days, except in Northern Ireland, where 200 has been adopted) are regarded as part-time holdings; on this basis half the holdings were part-time, though an analysis in 1955 showed that a third of the occupiers of such part-time holdings in England and Wales had

another full-time occupation. Part-time holdings were also shown to be most numerous around the large cities and in Wales and southwest England. In Scotland only 43 per cent of the holdings were full-time; as might be expected, part-time holdings were most numerous in the crofting counties of the northwest. In Northern Ireland nearly two-thirds of the holdings were part-time, although these included some 20 000 holdings which are let seasonally and generally run with other farms. There are no comparable data for the Irish Republic, but fewer than half of those occupying holdings of less than 30 acres gave their principal occupation as farmer in the 1961 census.

There are also great contrasts in agricultural land tenure throughout the British Isles. In Ireland nearly all farmers own the land they farm (or are paying annuities to acquire it), although there is both common grazing and some moorland held jointly by a number of owners in undivided shares. There is also a form of short-term tenancy known as conacre, where land is let for eleven months or less, mainly for grazing; such land represents about 10 per cent of the land used for agriculture. The proportion of owner-occupiers is much smaller in Great Britain, although it has risen considerably since the beginning of this century, when most farms were tenanted. Most holdings are either owned or tenanted, but some consist of mixed tenures. In England and Wales about 57 per cent of holdings and half the agricultural land were owned or mainly owned by occupiers, while in Scotland the proportions were 38 and 59 per cent respectively. There are, however, considerable regional differences and, as Fig. 98 shows for 1941, tenancy was then the characteristic form of tenure in northern England, while owner-occupation was more important further south. A special form of tenancy is found in the seven crofting counties in northern Scotland (Argyll, Caithness, Inverness, Orkney, Ross and Cromarty, Sutherland and Zetland) where occupiers of certain small holdings enjoy a high degree of security of tenure under the supervision of a Crofters Commission. There are about 20 000 such crofts, occupying some 72 800 hectares (180 000 acres) of improved land and 166 000 hectares (410 000 acres) of rough grazings, and crofters also have grazing rights over some 49 000 hectares (1.25 million acres) of common pastures. However, the legal position of tenants in general has improved steadily since the 1870s and they now enjoy a high degree of security of tenure and freedom of action, provided land is properly farmed. Statutory smallholdings have also been created, originally to foster a peasant economy, and then to help ex-servicemen to settle on the land after the First World War and to alleviate unemployment in the 1930s. In England and Wales there are some 15 000 owned by county councils and 1300 owned by the Ministry of Agriculture, while in Scotland the Department of Agriculture owns 4000 holdings, mainly in the crofting counties.

Many of the changes in the number of holdings in the United Kingdom since the middle of the nineteenth century have concerned small holdings

which are not farms, and the number of farmers has remained remarkably stable until recent years when it has begun to decline; numbers of farm workers, on the other hand, have fallen steadily.

## Types of farming

There are marked contrasts between one part of the British Isles and another in type of farming; and, while in many localities a variety of types can be found, individual types often show a tendency to be localised in particular regions. The reasons for these differences are to be found primarily in the physical condition of the land, in relief, soil and climate; but accessibility, especially to roads and hence to markets, farm size and type of tenure also play a large part. Furthermore, although hill sheep farms would seem to have little connection with intensive market gardening, in reality British farming forms a closely integrated whole. As has been shown, hill farms provide lowland farms with young stock for fattening, as well as some breeding animals, the surplus calves from dairy farms are sent elsewhere for fattening, and crop farms in eastern counties may provide those further west with fodder. Farms throughout the United Kingdom are thus linked by complex transfers of stock and crops and there are similar movements of stock in Ireland, as well as between the Irish Republic and the United Kingdom. Formerly this integration was achieved almost wholly through farmers buying in the cheapest market and selling in the dearest, although traditional links between one area and another may have played a part. There is, however, a growing tendency (if still on a small scale) for widely separated farms of different kinds to be permanently linked in this way under the same ownership or management; for example, a mixed farm in the English Midlands may be worked in conjunction with an upland farm in Wales owned by the same farmer. These links between different areas must always be remembered when the various types of farming are under discussion.

Types of farm can be recognised by reference to the relative importance of the enterprises, such as crop production, dairying and pig-keeping, which make up the farming system; many of these have already been discussed in the preceding sections on crop and livestock distributions. In the past, farm types were recognised on the basis of both land use and a subjective assessment of enterprises; thus, on the *Types of Farming* map prepared in 1937 by the Ministry of Agriculture and Fisheries, a threefold division was made in respect of the proportion of arable and grassland and these areas were then subdivided according to what were thought to be the leading enterprises. It is now widely held that all land which can be ploughed benefits from being so treated, and the spread of ley farming has blurred the distinction between arable and grassland and made this criterion less useful. More recently attempts have been made to make more objective estimates of the contribution which different enterprises make to the farm

business. For this to be done some common measure has to be found by which the relative importance of the various crops and livestock can be compared. Sales of farm produce would seem an obvious choice, but there is little information about these, and most studies have used estimates of labour requirements, calculated from crop acreages and livestock numbers by means of standard factors. Farms are classified according to the enterprise which accounts for half or more of the labour requirements, although some note is also taken of other enterprises. Those farms where no enterprise accounts for 50 per cent are classified as mixed, but it must be appreciated that many other farms have a number of enterprises. Unfortunately, classification in the various parts of the United Kingdom is not identical. In England and Wales in 1965 farms of the following type were recognised:

| *Type* | *Number* |
|---|---|
| Dairy | 60 800 |
| Livestock | 24 700 |
| Pigs and poultry | 9 600 |
| Cropping | 26 600 |
| Horticulture | 15 000 |
| Mixed | 19 500 |

Only full-time farms have been classified. Livestock farms are those which concentrate on the rearing and/or fattening of sheep and cattle; 4400 of these are mainly sheep farms in hill areas and correspond broadly with the hill sheep farms recognised in Scotland. A further 8400 are also in hill areas, but rely on both sheep and cattle and resemble to some extent the upland farms in Scotland.

In Scotland in 1965 the following types of farm were recognised:

| *Type* | *Number* |
|---|---|
| Hill sheep | 1300 |
| Upland | 2900 |
| Rearing with arable | 4800 |
| Rearing with intensive livestock | 1100 |
| Arable rearing and feeding | 2000 |
| Cropping | 3500 |
| Dairy | 7000 |
| Intensive | 1200 |

Of the three types of mixed rearing and arable farms, the emphasis in the first is on the rearing of sheep and cattle, in the second on cattle, pigs and poultry, and in the third on the rearing and fattening of cattle. About half the intensive farms are specialist pig and poultry farms and the remainder horticultural holdings.

In Northern Ireland in 1964 the following types were recognised:

| *Type* | *Number* |
|---|---|
| Mainly dairying | 9900 |
| Beef and sheep | 5700 |
| Mixed | 6200 |
| Pigs and poultry | 1400 |
| Cropping | 900 |

These figures alone give some indication of the regional differences in farm type, but the reality is far more complex. The distribution of different types of farm in Scotland in 1952 has been shown in a publication by the Department of Agriculture and Fisheries, *Types of Farming in Scotland*, but the predominance of moorland helps to make the pattern of farming in Scotland somewhat simpler than that in England and Wales, where farm types have not yet been mapped in detail. Some idea of their complexity can be gained by examining a map, based on a sample of holdings, which appears in a publication by the Farm Economics Branch of the University of Cambridge, *Farming in the Eastern Counties*. The following account summarises the main features of the principal types and should be read in conjunction with the generalised *Types of Farming* map of Great Britain, published by the Association of Agriculture. Reference should also be made to a new mapping technique based upon computerised farm data, published in *Outlook on Agriculture*, 5, 1968.

## Hill sheep farming

Most of the moorlands which cover one-third of Great Britain and also those in Ireland are grazed by sheep of hardy breeds. The flocks are mainly on hill sheep farms, which are unusual among farming types in that the breeding of sheep is often the only enterprise, chiefly because the land is too poor or the climate too harsh for any other kind of farming to be practised. On a hill sheep farm most of the land is rough grazing and, in general, the poorer the land the larger the size of the farm. There are usually several enclosed fields where fodder may be grown or where ewes may lamb, but winter feed is a major problem. In the uplands of England and Wales, the occupiers of such farms may have rights to pasture their sheep on common grazings, which often tend to be overstocked. Although large in area, hill sheep farms are often small as businesses and may employ only a single shepherd; both the carrying capacity and the income per acre are low. The main products from such farms are wool, store lambs sold in the autumn for fattening, and ewes sold for breeding on lowland farms. Only wool has a guaranteed price in the United Kingdom and prices of stock may fluctuate widely; the hill sheep subsidy, under which a payment may be made for each breeding ewe, was introduced to meet this problem.

## Livestock rearing

The only other enterprise likely to be found on hill sheep farms is the breeding and rearing of hardy cattle, but at lower elevations, where the proportion of improved land is higher, cattle form a main enterprise, often with a subsidiary sheep flock. Such farms occupy a smaller area, but grow more fodder crops; their output per acre, however, is still low by comparison with lowland farms. Cattle may run on the rough grazings in summer, but are kept on the improved land in winter. Cows normally calve in spring and calves are often sold in the autumn, although they may be kept longer if adequate feed is available. Except where stock can be fattened, wool is again likely to be the only product which has a guaranteed price, and the hill cow subsidy was introduced to help such farmers on marginal land.

## Dairy farming

Dairying is the most important enterprise on many farms in the lowlands, especially in western England and Wales, and in the southwest of both Ireland and Scotland. Such dairy farms are generally small in area, but dairying is a much more intensive enterprise than livestock rearing and output per acre is high. In Ireland there are few large urban markets and milk is mainly manufactured, but in Great Britain most milk goes to the towns for consumption as liquid milk and only the surplus is manufactured. Nevertheless, except in the case of cities like Aberdeen, which are remote from the main centres of population, proximity to markets is not a major determinant of the location of dairy farms, most of which are to be found in areas of moderate rainfall and mild climate where good grass can be grown and there is a long grazing season. Dairying may also be found combined with crop production and other enterprises in drier eastern areas, where there is an emphasis on more profitable winter milk production. In the 1930s and 1940s dairying became important on large farms on the chalk downs in counties such as Hampshire and Wiltshire. Since the mid-1950s, there has been a tendency for occupiers of dairy farms in eastern districts to give up dairying, since other enterprises have proved more profitable; dairy farms are thus becoming more localised in western counties of Great Britain.

## Beef fattening

Beef cattle are rarely the main enterprise on farms in the British Isles and many of the farms on which beef cattle are reared and fattened in England and Wales are included in either the livestock category or, if livestock are not sufficiently important, in the class of mixed farms; however, there are farms in areas of good grazing, like the east Midlands, where beef cattle are the major enterprise. Such farms are much more important in Scotland, especially the northeast where there are many arable and feeding farms. In Ireland, where many beef fattening farms are found in the plains of Meath, the emphasis is on fattening on grass.

## Mixed farming

In one sense, nearly all farming in the British Isles is mixed farming, in that there is more than one enterprise on most farms; but mixed farms in which no single enterprise predominates are to be found mainly in western England. The occupier of such a farm may keep both beef and dairy cattle, grow and sell some crops, and keep pigs and poultry; but such diversity is becoming increasingly uncommon as economic pressures encourage farmers to simplify their farming systems.

## Crop farming

Farms on which crops account for at least half the labour requirements are found mainly in eastern England and Scotland, where much of the land suited to arable farming lies and the climate is more favourable to crops and less favourable to grass than in any other part of the British lowlands. Such farms are generally well above average size and there are strong economic forces encouraging further enlargement. Barley, wheat, potatoes and sugar beet are the principal crops sold, although field crops of vegetables, like peas for canning and quick freezing, are of increasing importance. Most crop farms have other enterprises, such as pig and poultry keeping and the fattening of cattle in winter, but there is a growing (though small) number of crop farms on which there are no livestock at all.

## Horticulture

Horticultural crops were once grown very largely in market gardens on the margins of towns, but though specialist horticultural holdings are still found in such localities they are most numerous in areas like north and mid-Kent, the Vale of Evesham, mid-Bedfordshire and the Fenland. Most horticultural holdings produce both fruit and vegetables, and less than a third have more than half their business in either fruit or vegetables. Such holdings are generally small when measured by acreage, but represent a very intensive type of agricultural production. They are often highly specialised with subsidiary enterprises playing a minor part.

## Pigs and poultry

Farms specialising in pigs and poultry are also small when measured by the land they occupy, but they, too, are very intensive and the degree of specialisation is often marked. This is particularly true of holdings specialising in poultry, for the last decade has seen the rise of large broiler units and poultry flocks; in lowland England, where most pig and poultry farms are found, nearly two-fifths of laying birds and more than two-thirds of broilers are on specialist poultry holdings. Pig and poultry holdings are widely

scattered throughout the lowlands, but are most numerous in eastern and southeast England, reflecting the dependence of this type of farm on cereal feeding stuffs, and in Lancashire.

More detailed accounts of the distribution of different types of farming will be found in the chapters which follow on the agricultural regions of Scotland, England and Wales, and on Northern Ireland and the Irish Republic.

## The agricultural output of the United Kingdom and the Irish Republic

We are now in a position to examine the relative values of the principal types of produce which are sold off British farms. These figures take no direct account of produce retained on the farm, most of which is used to feed livestock, nor of the large purchases of feeding stuffs.

The figures for the United Kingdom, which show the position in both 1925 and 1965, illustrate the importance of livestock and livestock products at both periods, despite the very considerable changes in agriculture which have taken place in the interval.

*Agricultural output of the United Kingdom (value)*

| | 1925 PER CENT | | 1965 PER CENT | |
|---|---|---|---|---|
| Cereals | 10.5 | | 12.6 | |
| Potatoes | 5.2 | | 4.0 | |
| Sugar beet | 0.5 | | 2.1 | |
| Others | 4.0 | | 0.6 | |
| *Total farm crops* | | 20.2 | | 19.3 |
| Livestock | 36.2 | | 34.8 | |
| Milk and milk products | 26.4 | | 19.6 | |
| Other livestock products | 9.3 | | 15.3 | |
| *Total livestock and livestock products* | | 70.8 | | 69.7 |
| Fruit | 3.5 | | | |
| Vegetables | 3.1 | | | |
| Other horticultural products | 2.4 | | | |
| *Total horticultural products* | | 9.0 | | 10.9 |

Among livestock products, the most important change has been the sharp increase in egg production. Cattle now account for 36 per cent of the livestock output, pigs for 35 per cent, poultry for 17 per cent and sheep for 13 per cent.

The contribution of livestock and livestock products is even more marked in the Irish Republic. The corresponding proportions for 1965 are:

| | | |
|---|---|---|
| Cereals | 7.7 | |
| Potatoes | 3.0 | |
| Sugar beet | 3.0 | |
| Other crops | 3.8 | |
| Total crops (including fruit and vegetables) | | 17.5 |
| Livestock | 52.3 | |
| Milk and milk products | 23.9 | |
| Eggs | 4.9 | |
| Other livestock products | 1.4 | |
| Total livestock and livestock products | | 82.5 |

The high proportion contributed by livestock is in part a reflection of the suitability of the British Isles for grass and grazing livestock and, equally, of its unsuitability for crops. It is also related to the high standard of living of most of the inhabitants and to the advantages of proximity to markets enjoyed by those who produce perishable products like fresh milk. In interpreting these figures, account must also be taken of the fact that half the food consumed in the United Kingdom is imported, whereas the Irish Republic is a net exporter; a third of the coarse grain used to feed livestock is also imported into the United Kingdom, representing a quantity more than ten times as large as the imports of coarse grain into the Irish Republic.

## Some agricultural industries

### Sugar beet

One of the most remarkable features in the history of sugar is the fact that the British Isles remained for so long without a homegrown sugar industry, despite the existence of a large sugar beet industry in continental Europe, where the first sugar beet factory had been established as early as 1801. Efforts to establish factories in this country were made from 1909 onwards, factories were planned, and promises were extracted from farmers to grow the necessary beet. But the competition of bounty-fed cheap continental sugar in the open British market rendered all these schemes abortive. It is interesting to note, however, that the Cantley factory was built in 1912 before the First World War, very largely with Dutch capital, and thus the beginning of the modern industry in this country was mainly due to Dutch initiative. It was, of course, during the First World War that the United Kingdom felt the severe effects of not having a home sugar industry, for the shipping necessary to bring supplies of sugar to the British Isles could ill be spared. The normal imports of sugar had approached 2 million long tons, so that supplies had to be carefully rationed in wartime. In March 1917 the Treasury sanctioned an advance of £125 000 to the British Sugar Beet

Society as a loan for the development of the Kelham estate in Nottinghamshire, but for various reasons the factory was not ready to operate until March 1921. In the meantime, the Cantley factory, which had been disused during the war, was reopened in 1920, and took beet which had been grown for the then uncompleted Kelham factory. At that time there was an import duty on sugar and great assistance was given to the home industry in March 1922 by the remission of the excise duty; but it was recognised that high import duties could not be maintained indefinitely. The passing of the British Sugar Subsidy Act, in March 1925, marked the beginning of a long and complicated story of direct state aid to the home sugar industry.

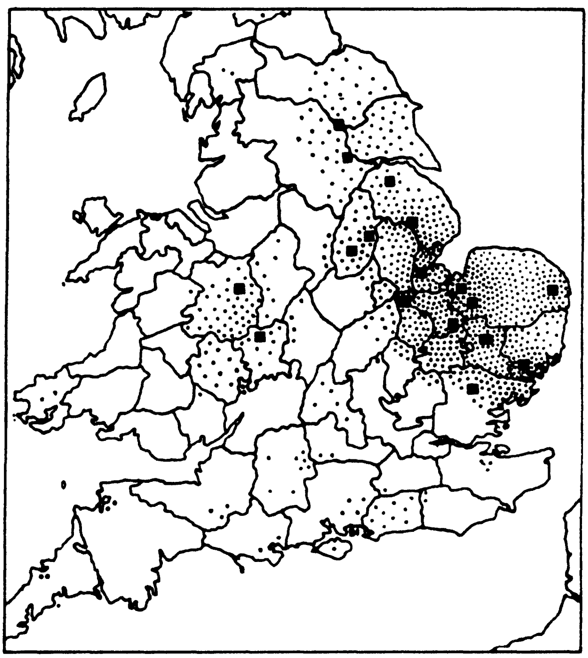


FIG. 99. Sugar beet in England and Wales
Each dot represents 500 acres of sugar beet in 1951–52. Each square represents a beet sugar factory.

By 1927–28 seventeen factories in England had been established and by 1930–31 the industry had taken on almost the pattern it still has nearly forty years later. Since 1942 the area under sugar beet has changed little and now stands at some 182 000 hectares (450 000 acres). There is one factory in Scotland at Cupar in Fife; two factories are located in the west Midlands, at Kidderminster and Allscott (Shropshire). The remaining fifteen, at Bardney, Brigg, Bury St Edmunds, Cantley, Colwick, Ely, Felstead, Ipswich, Kelham, King's Lynn, Peterborough, Poppleton, Spalding

and Wissington, are all in eastern England in an area stretching from Yorkshire to Essex (Fig. 99).

By 1931 the average yield of sugar beet was 17 800 kilograms per hectare (7.1 tons per acre) and the sugar content 17.3 per cent. The yield of beet has climbed steadily from 23 800 kilograms per hectare (9.4 tons per acre) in 1938–48 to 38 350 kilograms per hectare (14.4 tons per acre) in 1959–62 and the sugar content has also increased. The production of sugar thus averaged over 3765 kilograms per hectare (1.5 tons per acre) and has been maintained at 600–700 000 long tons (1951–60) or more than a quarter of British consumption.

The conditions necessary for the cultivation of sugar beet agree in general with those required for other root crops. It requires a well-drained fertile loamy soil, whilst a certain proportion of lime in the soil is essential. It is an annual plant raised from seed and sown in the spring. The whitish parsnip-like roots are ready for digging towards the autumn; they are washed and topped and are then ready for delivery to the factory, where the sugar is extracted. The pulp or residue from the beet makes excellent manure applied either direct or as dung from the cattle fed on it, and there is a steadily increasing demand in this country for wet pulp mixed with molasses, for it is both a palatable and a valuable cattle food. Two difficulties in the establishment or maintenance of the sugar beet industry must be mentioned. One is the need for close cooperation between the factories and the farmers, for the supply of sugar beet must be assured from year to year. The second difficulty is that sugar beet is a heavy, bulky commodity and transport costs are heavy, so that little beet is grown more than forty miles from a factory. At the same time, beet must be grown in rotation with other crops, and the amount of land which can be sown to beet immediately around the factory, however large it may be, is therefore strictly limited. These factors tend to restrict the size of the factories which are possible in the British Isles.

A similarly protected sugar beet industry has grown up in the Irish Republic where there are factories at Carlow, Mallow, Thurles and Tuam.

## The canning industry

One of the spectacular developments in British agricultural industries in the years between the wars was the rise of the canning industry. There is no official return of output, but the following table gives an estimate of the output of canned fruit and vegetables in the 1930s when the great rise occurred. In seven years the output increased tenfold, from under 10 million cans in 1925 to over 100 million cans in 1932. Towards the close of 1932 there were nearly sixty factories (ten of which had come into production during that year) employing mass production automatic machinery.

*The early rise of output of British canned fruit and vegetables* (*cans*)

| | | | |
|---|---|---|---|
| 1913 | negligible | 1929 | 16 340 000 |
| 1924, 1925 | very small | 1930 | 34 200 000 |
| | | 1931 | 83 000 000 |
| 1926 | 7 000 000 | 1932 | 100 000 000 |
| 1927 | 7 840 000 | 1934 | 120 000 000 from 76 factories |
| 1928 | 7 930 000 | | |

In the past one of the great difficulties faced by the British farmer growing fruit and vegetables for market has been the shortness of the season. Too often a good season means a good season for everybody, a glut of fruit and vegetables and very low prices. Canning provides a way of dealing with such a glut; provided the area of production is near the cannery, the fruit can be picked when the weather is suitable and the operation of canning completed within twenty-four hours. A danger is that sufficient care will not be taken in the grading of the fruit for maintenance of quality is essential for the prosperity of the industry. Similarly, it is undesirable for fruit to be brought from a distance and to suffer the disadvantages of carriage before being canned. Consequently the major canning factories in Great Britain are near the main areas of production, especially East Anglia. The shortness of the season also affects the economic working of the canning industry. Broadly speaking, fruit and vegetables are available for canning in this climate only for about four months, from June to September. To run a factory and to secure an adequate labour supply for four months out of the twelve is difficult. If a canning factory can be built near the seaboard, for example, at Ipswich, it may be possible to combine the canning of fish with fruit and vegetable canning, so as to occupy the machinery for the greater part of the year.

The canning industry suffered a severe setback during the Second World War, partly because of the scarcity of tinplate. Thus, 32 000 metric tons of fruit were canned in 1938, but an average of only 4000 metric tons in 1939 1943. Production recovered quickly after the war and reached 94 000 metric tons in 1955.

The quick freezing of vegetables (especially peas), fruit and fish began in earnest about 1947. The quantity of frozen vegetables increased rapidly from 2882 metric tons in that year to 68 000 in 1961, as did the tonnage of fish, which reached 56 000 metric tons in 1961. There was only a small increase in frozen fruit which rose from 1000 to 1500 metric tons. There are now over twenty major establishments in the growing areas.

There are also canneries in the Irish Republic, especially in Cork and Dublin; quick freezing plants have been erected by the Irish Sugar Company.

## The brewing industry

Since a large quantity of homegrown barley and homegrown hops are used in beer making, brewing may be classed as an agricultural industry. In the manufacture of beer, the barley is first malted, then ground into coarse meal and mixed with warm water. After this liquid, or wort, is strained off, the remains of the barley are dried and sold to farmers as a valuable cattle food. From about 560 kilograms (11 cwt) of barley about 150 kilograms (3 cwt) are thus returned to the farmer for use in feeding his cattle, and in many ways this cattle cake is a better feed than the original barley itself. The wort is then boiled with hops and fermented.

The brewing of beer used to be carried out mainly in small farmhouses, but it has become more and more concentrated into large breweries; even the smaller breweries are disappearing. One reason is the precision needed at each stage in the complex operation. For example, the quality of the water used in the malting process is very important. The best results are obtained from water which possesses a considerable permanent hardness due to the presence in solution of calcium sulphate. The well water from the Keuper Marls at Burton-on-Trent is of this character and is therefore particularly suitable; the brewing industry of that town is no doubt largely a result of this supply. Manchester, Warrington, Chester, Liverpool and Tadcaster are other brewing centres situated on the Trias, but in some cases the salt is added artificially to the water (the process commonly known as 'burtonising').

The annual consumption of beer in the United Kingdom (1951–62) is between 24 and 30 million barrels, a barrel containing 145.5 litres (32 gallons or 256 pints); this is about 68 to 85 litres (120 to 150 pints) per head of population per year. Consumption reached its highest level in 1945 (33 million barrels), but later dropped steadily, only to rise again to 27.9 million in 1962.

## Distilling

There are three stages in the manufacture of whisky: malting and mashing the barley, or the preparation of the wort, as in the manufacture of beer; the fermentation of the wort to produce the wash, and the separation of the spirit from the wash by means of distillation. For Scotch whisky, barley is practically the only material used. In Irish whiskey, barley, oats, wheat, and rye are generally mixed.

Despite the decrease in consumption which is due to high excise duties, changes in popular taste and the demands of the export trade, especially to America, whisky may still be regarded as the native drink of Scotland and Ireland, as beer is of England. In 1913–14 nearly 123 million litres (27 million proof gallons) were consumed in the British Isles (81.3 million litres (17.9 million gallons) in England and Wales, 28.1 million litres (6.2 million gallons) in Scotland and 10.4 million litres (2.3 million gallons) in

Ireland) representing 2.27 litres (0.5 proof gallon) per head of population. By 1926–27 the total had fallen to less than 54.5 million litres (12 million gallons) (38 million litres (8.4 million gallons) in England and Wales; 14 million litres (3.1 million gallons) in Scotland), representing only about one litre (0.24 proof gallon) per head of population. In the decade 1941–50 total consumption of all spirits (i.e. whisky, gin, rum and brandy) in the United Kingdom dropped to between 36 and 46 million litres (about 8 and 10 million gallons). As home consumption has fallen, so exports have increased, both to North America and to continental Europe; indeed, markets are worldwide.

## The food supply of the United Kingdom

The introduction of subsidies and the changing value of money render invalid comparisons between present and past expenditure on food, whether by the individual or the nation, but a comparison of quantities per head of population is both interesting and instructive.

The following table shows some striking changes since the early part of the present century. There is no doubt that the British people are now better fed than ever before, although supplies of meat, bacon, butter, eggs and fruit were greatly curtailed during the Second World War. The war left a surprising legacy in the continued high consumption of potatoes, although this in part represents a change of habit in a rising consumption of manufactured potatoes, such as potato crisps. Compared with sixty years ago, there is less reliance on bread and the amount of butcher's meat is lower, although this figure conceals considerable changes in the pattern of meat consumption; for whereas 16 per cent of home-killed meat was pork before the Second World War, the proportion is now 29 per cent. One of the most striking changes is the increase in consumption of poultry meat which is now more than three times as large as in the 1930s, a consequence of the spread of broiler production and the relative cheapness of poultry compared with other kinds of meat.

As has already been noted, despite an increase in population, the United Kingdom is now less dependent on imported food than before the Second World War. Forty-seven per cent of wheat is now home grown, compared with 23 per cent; 70 per cent of carcase meat is home produced, compared with 51 per cent; 98 per cent of shell eggs compared with 71 per cent, and 43 per cent of cheese compared with 24 per cent. But the dependence on imports of oils and fats (89 per cent imported) and butter (92 per cent imported) is greater and most of the bacon consumed is still imported.

The figures for 1907 are calculated from the *Agricultural Output and the Food Supplies of Great Britain, HMSO*; those for liquid milk and eggs are estimates from numbers of gallons and eggs respectively. The remaining figures are taken from the *Annual Abstract of Statistics* and are not strictly

comparable; the figures given for bacon and ham include all pig-meat and lard.

*Estimated food supplies in the United Kingdom in pounds and kilograms per head per annum*

| COMMODITY | | 1907 | 1934–38 AVERAGE | 1946 | 1965 |
|---|---|---|---|---|---|
| Flour | lb | 208.0 | 194.5 | 221.2 | 155.2 |
| | kg | 94.3 | 88.3 | 100.3 | 70.4 |
| Sugar | lb | 79.9 | 100.6 | 79.5 | 110.4 |
| | kg | 36.2 | 45.5 | 36.1 | 50.0 |
| Fresh and frozen meat | lb | 102.0 | 92.4 | 70.8 | 92.6 |
| | kg | 46.2 | 41.9 | 32.0 | 42.0 |
| Bacon and ham | lb | 42.8 | 26.4 | 15.1 | 25.7 |
| | kg | 19.4 | 12.0 | 6.8 | 11.6 |
| Poultry | lb | — | 5.1 | 4.0 | 16.5 |
| | kg | — | 2.3 | 1.8 | 7.5 |
| Fish | lb | 43.5 | 21.8 | 26.3 | 17.8 |
| | kg | 19.7 | 9.8 | 11.9 | 8.1 |
| Liquid milk | lb | 195.0 | 217.1 | 309.4 | 325.2 |
| | kg | 88.5 | 98.4 | 140.3 | 147.5 |
| Cheese | lb | 8.8 | 8.8 | 10.0 | 10 1 |
| | kg | 4.0 | 4.0 | 4.5 | 4.5 |
| Eggs shell | lb | 14.2 | 25.9 | 18.0 | 32.0 |
| | kg | 6.4 | 11.7 | 8.1 | 14.5 |
| Butter | lb | 15.9 | 24.7 | 11.0 | 19.5 |
| | kg | 7.2 | 14.0 | 4.9 | 8.8 |
| Margarine | lb | 4.9 | 8.7 | 15.1 | 12.0 |
| | kg | 2.2 | 3.9 | 6.8 | 5.4 |
| Dried and fresh fruit | lb | 74.1 | 86.5 | 60.0 | 79.1 |
| | kg | 33.6 | 39.2 | 27.2 | 35.9 |
| Canned and bottled fruit | lb | - | 10.3 | 2.4 | 18.7 |
| | kg | | 4.6 | 1.1 | 8.4 |
| Potatoes | lb | 188.8 | 190.0 | 281.2 | 223.2 |
| | kg | 85.6 | 86.1 | 127.5 | 101.2 |
| Fresh vegetables | lb | · | 115.3 | 130.7 | 115.2 |
| | kg | · | 52.3 | 59.3 | 52.2 |

Before the sources from which the United Kingdom derives her food are considered, it is necessary to have at least a generalised picture of the changing pattern of world trade.

Before the First World War many of the 'newer' countries were producing a surplus of food (including animal feeding stuffs) and raw materials which they were anxious to exchange for British manufactured foods and were sometimes even willing to 'dump' or sell below cost. The United

Kingdom had many investments overseas and payment of interest came largely in the form of foodstuffs, as did payment for services rendered, such as banking, insurance, shipping and technical services. Tariff barriers were comparatively few and the flow of world trade was unhindered. British supplies of food could have come from many areas: they tended to come from those countries with which the United Kingdom had the closest ties.

The submarine menace of the First World War, shortage of shipping and the spectre of starvation turned attention, if only temporarily, to increasing home supplies of food, but when that war was over, home production became an even smaller proportion of total consumption than before. There was, however, a deliberate attempt to stimulate trade within the British Commonwealth. Empire Free Trade became a slogan, the Empire Marketing Board was set up and various trade agreements involving imperial preference were negotiated. The increase of food imports from Commonwealth countries was only a little greater than the increase from foreign countries.

The advent of the Second World War brought many changes. There was the tremendous drive to increase food production at home while the Ministry of Food undertook the planning of the nation's diet. The Government purchased in bulk both the home production and overseas supplies and then rationed the total amongst the civilian and service populations. Private wholesale trading in food practically disappeared. When the war was over, relaxation of controls and the return to private trading took place very slowly. The international situation was completely changed as far as the United Kingdom was concerned. There was no longer any automatic flow of food into the country as interest on overseas investments, for the investments had for the most part been sold or otherwise liquidated to pay for the war. The world was divided into blocs: the Soviet bloc behind the Iron Curtain which played little part in foreign trade; the dollar countries; and the sterling area (the Commonwealth and certain other countries linked with the £ sterling—see Fig. 279). There was comparatively free trading between members of the sterling area, but shortage of dollars resulted in stringent restrictions on food imports from the United States and, despite membership of the Commonweath, from Canada. Whereas, therefore, comparisons between the sources of supply of food for the United Kingdom before and after the First World War indicate changes in the world's supply position, such comparisons of before and after the Second World War reflect the influence of manmade barriers.

The change in origin of wheat and wheat flour supplies is particularly noteworthy. Before the First World War huge quantities came from the United States, but later Canada became easily the chief source, followed by the United States, Argentina and Australia, these four countries providing on average over 90 per cent of the total. The pre-1914 supplies from Russia have, of course, almost disappeared. Of other grains imported, maize was very important in the interwar years as food for livestock, and

1.77 million metric tons (1.75 million long tons) were imported annually, five-sevenths coming from Argentina, one-seventh from South Africa, and the remainder from Romania and the United States; 60 per cent now comes from the United States. The United Kingdom imported annually 1.52 million metric tons (about 1.5 million long tons) of meat, of which over 1.2 million was chilled beef from Argentina; it is noteworthy that imports exceeded the home supply, only about 43 per cent of the beef consumed being produced in the United Kingdom in the interwar years. Imports now account for a quarter of supplies and Argentina is still the chief supplier. 250 million kilograms (5 million cwt), mainly of mutton and lamb, came from New Zealand and Australia, while the 250 million kilograms (5 million cwt) of meat from Denmark was mainly bacon; these countries remain the chief suppliers. Other supplies in smaller quantity came from the United States, Uruguay, the Netherlands and Canada, while a notable feature was the import of bacon from Poland. The increased home consumption of meat in the exporting countries is at least one reason for the shortage of world supplies of meat.

Nearly all eggs used in this country are now home produced, but imports reached 3000 million in the interwar years, half this huge quantity coming from Denmark and the Netherlands, rather less than a fifth from the Irish Republic and a tenth each from Poland and Belgium. Changes in world communications have been responsible for quantities of poultry coming from Australia and South Africa, whereas formerly the only country sending poultry to Britain was the Irish Republic; imports are now only a small proportion of consumption and come mainly from Denmark. In dairy produce there is practically no import of fresh milk, but considerable quantities of condensed milk are imported. Forty per cent of the butter imports came in the interwar years from the Empire, from New Zealand, Australia and Ireland, Denmark sent a third, and Argentina was another important source; New Zealand, Denmark and Australia are now the principal suppliers. New Zealand, easily first, and Canada provided 60 per cent of imports of cheese, the other countries being the Netherlands and Italy. The details for vegetables and fresh fruit deserve a chapter to themselves, because they illustrate in a remarkable way what can be done with improved methods of transport, as with the specially constructed ships with refrigerating machinery, to extend the markets for a commodity. Nevertheless, homegrown vegetables can compete satisfactorily in terms of quality with anything imported which is grown under similar climatic conditions.

British agriculture is now more efficient and productive than before the Second World War, but about a quarter of the temperate products which could be homegrown are still imported. There is considerable controversy about the proportion that should be produced in the United Kingdom, but there is little doubt that more could be, provided there were adequate incentives to farmers; but the British would lose the cheap food supplies they have enjoyed for over a century.

Strictly comparable figures are not available for the Irish Republic, but the pattern of food consumption is rather different. Ireland is, of course, a net exporter of food, importing only those products like hard wheat and tropical produce which cannot be homegrown. In 1965, only 28.8 kilograms (63.6 lb) of sugar were consumed per head, compared with 50 kilograms (110.4 lb) in the United Kingdom; consumption of meat was about the same, but that of fresh milk nearly 50 per cent higher, at 211 litres (46.4 gallons) per head, and of butter over 70 per cent higher. Less than half as much cheese (1.8 kilograms (3.9 lb)) was eaten in the Republic of Ireland, but consumption of potatoes (at 148 kilograms (326 lb)) was nearly 50 per cent larger. These differences reflect both the nature of Irish domestic production and the differences in the standard of living.

# 11
# The agricultural regions of Scotland

In his *Agricultural Atlas of Scotland*, H. J. Wood divided Scotland into a number of simple agricultural regions. Although the work of the Land Utilisation Survey enabled the regions to be defined more exactly, and although the production campaign of the years 1939 to 1945 wrought certain changes which have persisted, his regions were based on environmental factors which remain. It does not, therefore, seem necessary to change the regional division which has been used in the earlier editions of this book, though the map (Fig. 100) should be compared carefully with the

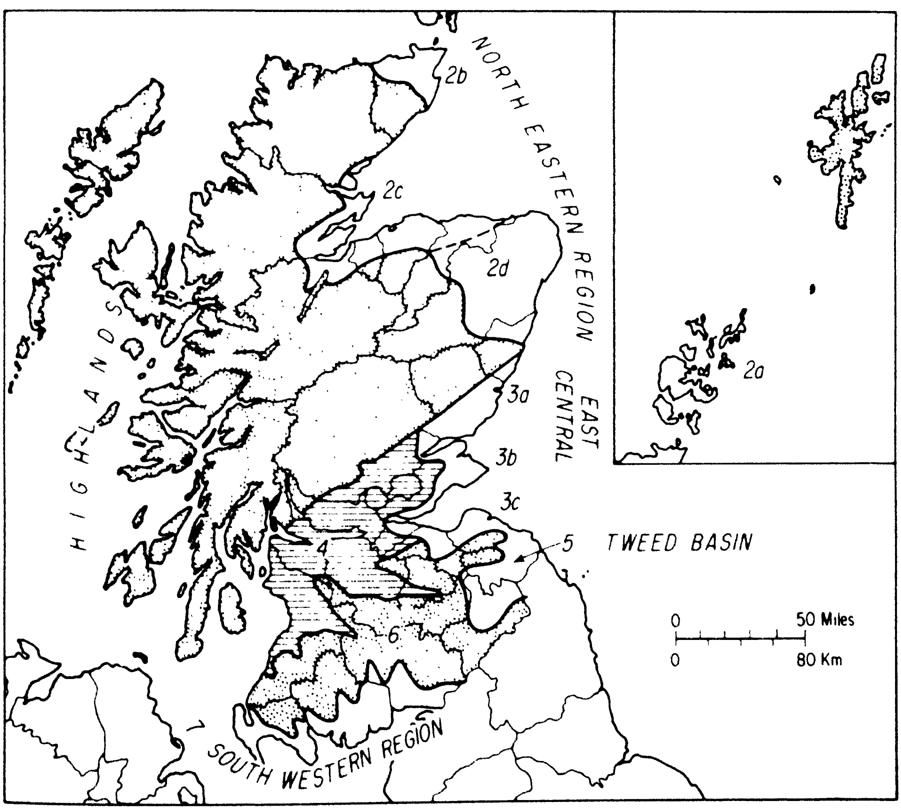



FIG. 100. The Agricultural Regions of Scotland (after H. J. Wood).

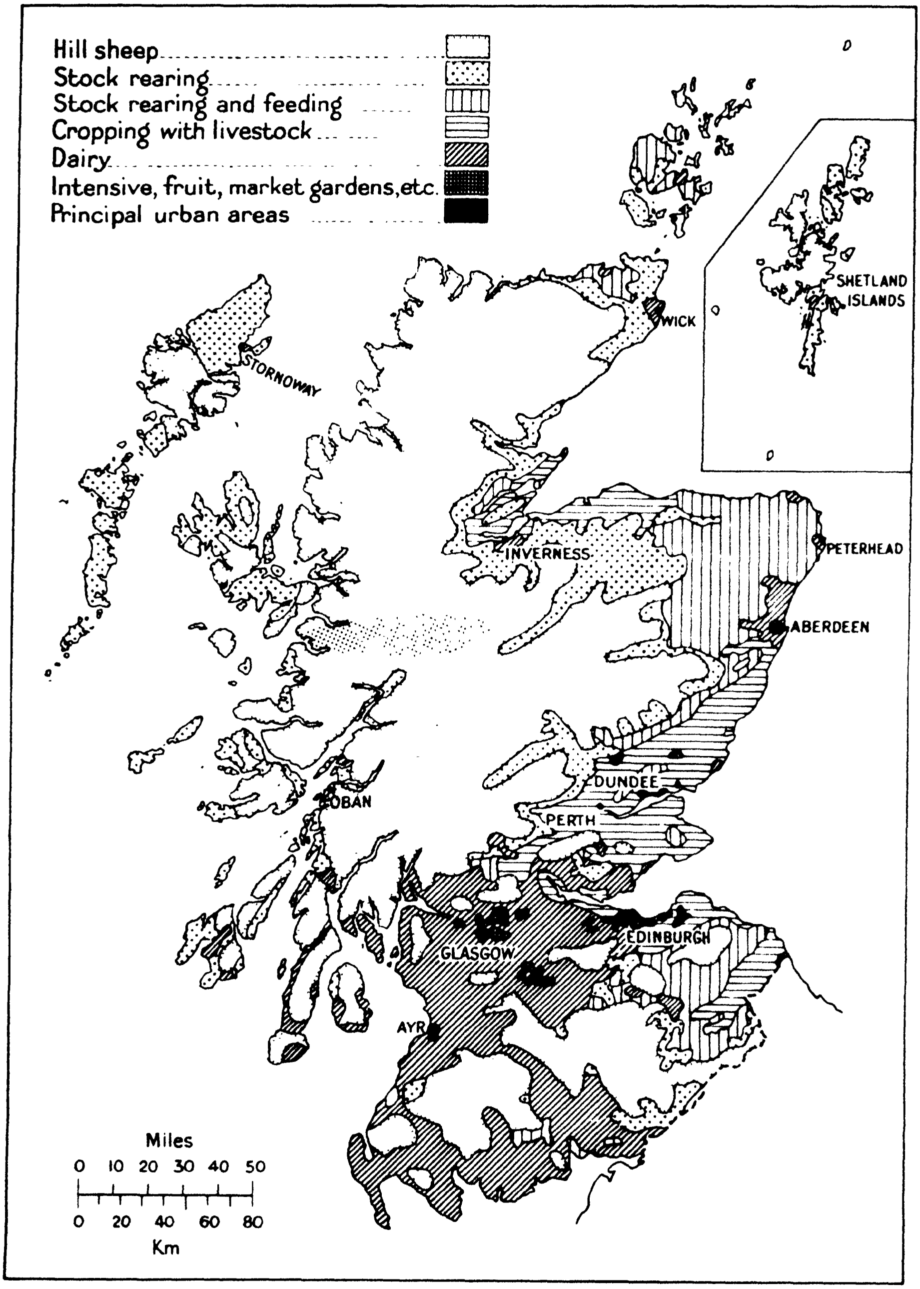



FIG. 101. Predominant types of farming in Scotland. This map refers only to full-time farms

(Modified from *Types of Farming in Scotland*, 1952, by permission of the Controller of H. M. Stationery Office

map of predominant types of farming prepared by the Department of Agriculture for Scotland (Fig. 101), which is itself a post-Second World War revision of the map based on statistics for 1938, and published at a scale of 1 : 625 000 in the National Planning Series.

For Scotland as a whole, it is remarkable that in the interwar years, 98.7 per cent of the total area occupied by crops and grass was represented by permanent grass, rotation grass, oats, barley, wheat, turnips and potatoes; the postwar position is very much the same. The specialist crops, which are sometimes of great importance in England, play a smaller part in Scotland and the relative distribution of these major crops thus gives a key to the farming economy of the various regions.

## The Highlands and Western Isles

The Highlands of Scotland form a well-marked region from both the physical and the agricultural points of view. It is the most extensive region in Scotland and includes all the islands, with the exception of the Orkneys. The southeastern boundary approximately follows the line of the Highland boundary fault; only here and there are valleys which belong rather to the fringing corridor of lowland. To the east the boundary with the north-eastern agricultural region is not a sharp one, Highland conditions disappearing gradually as one passes eastwards. Although there are variations within this huge area, it is generally true to say that there are central cores of highland virtually uninhabited by man and his domestic animals. These are the deer forests, though almost devoid of trees, which in 1938 occupied about 1.3 million hectares (3.3 million acres), nearly all in the Highlands, or 17 per cent of all Scotland. In that year only 3 per cent of the hill sheep were inside the deer forests, the bulk being found in hill sheep farms which occupied much of the remainder of the Highlands. These farms are large and generally have over 95 per cent of their area in rough grazings; but most have a small acreage under such feed crops as rape. Sheep are mainly Scottish Blackface and the ewes are eligible for Hill Sheep Subsidy. On the lower and rather better margins, the proportion of rough grazing declines and hill sheep-farming gives place to cattle-rearing. On the west coast and in the islands, crofting prevails. Crofters enjoy a special status as tenants, but most have other occupations as well; for crofts are generally too small to provide a living, even with access to common grazings. Formerly, many crofters combined fishing and farming, but few do so now; providing 'bed-and-breakfast' for summer tourists is less arduous and much more lucrative.

The hard, resistant old rocks, from which the great ice sheets swept much of the previously accumulated soil, have combined with climate to create conditions where only a few small areas are suitable for agricultural settlement. High rainfall, humid conditions, cool moist summers and a lack of sunshine result in an abundance of surface water and wide areas of moor and bog. Drainage is difficult and even where it has been carried out, the

wide extent of acid peat soils militates against cultivation. Limestone is rarely available locally to ameliorate the acidity. Towards the east conditions become slightly more favourable as the rainfall diminishes. But population densities are low and rural depopulation has long been the rule, as people gravitate towards more favoured agricultural lowlands or to urban centres, and to foreign countries where better opportunities await them. The drier or wider glens, especially those of the Tay system towards the east, and tracts along the western coastal fringe are the most suitable for settlement; permanent grass and small acreages of oats, turnips, potatoes and barley are found here. The Highlands remain a problem area. Recent developments include afforestation (see above, p. 144) and hydroelectric power (see below, p. 346). No longer are there wealthy tenants able to pay large sums for the rent of deer forests and hunting lodges, though shooting, especially on the drier grouse moors, is still popular and an important source of revenue. Hill sheep farms and cattle-rearing supply healthy stock to lowland farms, for fattening and breeding, and the future may in part depend on the improvement of hill grazings by the use of Stapledon's methods and the development of large-scale ranching.

## The northeastern region

This is a coastal region of varying width which can be divided into four parts:

The Orkney Islands;
The northeastern part of Caithness;
The Moray Firth lowlands;
The Buchan Plateau or the 'shoulder' of Aberdeenshire and Banffshire.

Most of the three northern tracts are underlain by Old Red Sandstone, and most of Aberdeenshire by granitic and metamorphic rocks, but there is generally a covering of drift which gives rise to moderately acid soils. The dominant crops are rotation grass, oats, turnips and, increasingly, barley. The summers are too cool for the ripening of wheat, but in the favoured areas, particularly around the Moray Firth and along the coastal strip from the Moray Firth to the shoulder of Aberdeenshire, barley is of considerable importance. There is extensive grazing for sheep and cattle on the fringes of the moors, but little permanent grass; where the land is improved it is ploughed and was once worked on a six-year rotation of oats, turnips, oats, grass, grass, grass. In this area, as in other parts of Great Britain, barley is now replacing oats as the leading cereal, at least on the lower lands. The economic development of this region owes much to the introduction of turnips, valuable both for fodder and as a cleaning crop. As shown on Fig. 101, each of the main towns (Thurso, Wick, Inverness, Peterhead and Aberdeen) has given rise to a small dairying area to supply local needs, but the larger coastal towns, with their interest in fishing, are rather apart from

the main agricultural belt as a whole. Over most of the remainder, stock rearing and feeding predominate, especially of beef animals of the Aberdeen-Angus breed, and farms are small. On the richer Moray Firth Lowlands the feeding is based on arable cropping. The areas as a whole are too remote for dairying to have developed on any scale and in recognition of this two separate Milk Marketing Boards were created, the North of Scotland and the Aberdeen and District. The Buchan plateau, with much of inland Banff and Aberdeen, is very extensively forested.

## The east-central region

This is the drier part of the Central Lowlands of Scotland. It is favoured by varied and often fertile soils, many of them derived from material of glacial origin, and by good climatic conditions, with drier sunnier summers than are usual farther north and an annual rainfall which is generally less than 760 millimetres (30 in) and sometimes less than 635 millimetres (25 in). Arable farming is the rule and farms are large. Commonly a six-year rotation is practised, of oats, potatoes, wheat, turnips, barley, grass; but in recent years barley has become a much more important crop. Sugar beet, vegetables and small fruit provide other cash crops. However, much of the produce of the arable land is devoted to the fattening of sheep and cattle.

The region is divided into three parts by the Firths of Tay and Forth:

(*a*) The Angus Region lies mainly in the county of that name, southern Kincardine and eastern Perth. It includes part of Strathmore and the coastal belt, and the Carse of Gowrie is noted for its small fruit, especially raspberries.
(*b*) The eastern half of Fife is an undulating lowland, where sugar beet, processed in the factory at Cupar, is a distinctive crop.
(*c*) The northern strip of West Lothian and Midlothian and the greater part of East Lothian, limited roughly to the south by the 150 metre (500 ft) contour, has long been famed as one of the most favoured agricultural regions of Scotland. Edinburgh and the other towns of the area have long exercised an influence, and this has resulted in the increased importance of market gardening and other forms of intensive cultivation.

## The west-central region

This region occupies the larger part of the Central Lowlands and has a higher rainfall, which may exceed 1500 millimetres (60 in) per annum in the west. The volcanic hills, with their rough sheep pastures, may be regarded as outliers of the Highlands from the agricultural point of view. The summers are cooler and wetter and have less sunshine than the eastern region, and thus the proportion of grass is high. Cereals other than oats are uncommon, but barley is increasing in importance; turnips play a smaller

part in farming economy here than they do in the east of Scotland, whilst potato production on a large scale is limited to certain localities. This is pre-eminently a dairying area, the home of the famous Ayrshire cattle, but the Carse of Stirling is noted for hay production, and the raised beaches along the coast of Ayrshire, with their sandy soils and mild spring weather, have given rise to a specialised early potato industry centred on the town of Girvan. The demand from the towns, especially greater Glasgow, obviously exercised an influence here, as it does noticeably on the main centres of the dairy industry. The old-established orchard area of Lanark is the only area in Scotland where top fruit is grown on any scale; it lies in the Clyde Valley and is protected from the winds which sweep over the uplands. The Clyde Valley also includes the largest concentration of glasshouses in Scotland.

## The Tweed Basin

The Tweed Basin is a mainly arable region of large farms; it is enclosed on three sides by moorland and extends into Northumberland. Permanent grass and rotation grass are of almost equal importance, barley is the leading cereal, and turnips (winter food for sheep) are still an important crop in a region where upland and lowland are integrally linked in a pastoral farming regime. Towards the mouth of the Tweed, the Merse of Berwick is distinctive in that it has a considerable acreage under wheat. Potatoes and other cash crops are unimportant. Cattle are numerous in the lower-lying districts of mixed farming, but the Tweed valley is unique in the whole of Scotland for the number of sheep it carries. In the upper basin, in Tweeddale, Ettrickdale, Teviotdale and Lauderdale, the density of sheep population is very high and large sheep farms are characteristic. The poorer sheep pastures support the Scottish Blackface, the better pastures at lower levels the Cheviots, whilst an improvement of breeds on lowland farms has been carried out by crossing ewes of these breeds with Border Leicester rams to produce the Greyface and the Scottish Halfbred respectively. An account of the woollen industry is given in Chapter 19.

## The Southern Upland region

The greater part of this region is occupied by moorland, but the Southern Uplands differ from the Highlands in their lower elevation, the gentler relief of the hills and the better grazing which they afford, and hence in the greater density of the sheep population. In the postwar period there has been extensive afforestation which has reduced the area under rough grazing, especially in the west. Settlements are mainly located in the valleys, and on the river terraces of these valleys there are fields, usually of permanent grass, sometimes of sown grass and less frequently of oats and turnips. Most of the larger valleys afford important routeways and the improved access which results led to the extension of dairying from the

lowlands on either side; in the west, rearing hill sheep may also be combined with the keeping of young dairy stock.

## The southwestern region

This lowland region borders the Southern Uplands from the head of Solway Firth in the east to Wigtownshire in the west. In the east are the dales which dissect the southern Uplands and in the centre is the coastal tract or the Rhinns of Galloway. In common with other parts of western Scotland the limit of cultivation is quite low, reaching 60 metres (200 feet) in Wigtownshire, but rising eastwards. The region has a relatively heavy rainfall of up to 1270 millimetres (50 in) and cloudiness is a characteristic feature. Wheat is little grown under such climatic conditions; oats were the principal crop, but have been giving way to barley in recent years. The greater part of the land is under permanent or sown grass. The whole region has large numbers of cattle, especially dairy cattle, usually Ayrshires; the native Black Galloway cattle are also characteristic. The mild climate allows a longer period of grass growth than elsewhere in Scotland. The manufacture of butter and cheese is far less important than formerly and quantities of milk are now sent to the towns of central Scotland; before the creation of the Scottish Milk Marketing Board, this area also supplied milk to Newcastle and other areas in England. There is a tendency, not so marked as in Ayrshire, to lay down under grass for as much as ten or even more years land which has been ploughed, and then to plough it for two or three years before laying it down again to grass. It is thus difficult to decide whether this is strictly rotation or permanent grass. Indeed, this is true of Scotland as a whole and in 1959 the distinction between permanent and rotation grass was abandoned in official statistics.

# 12
# The agricultural regions of England and Wales

It would be hard to find elsewhere in the world an area of comparable size to the British Isles with such a variety of agricultural conditions. Wide variation in types of soil consequent upon complicated geological structure

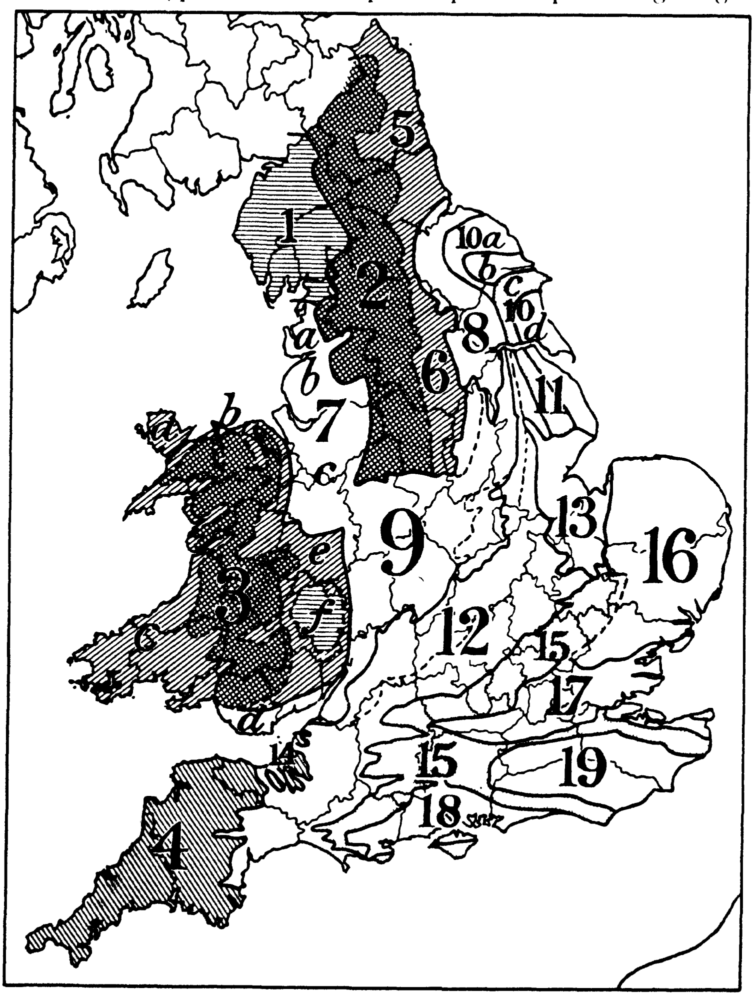



Fig. 102. The agricultural regions of England and Wales

and physiographic history, considerable variation in relief, and by no means unimportant differences in climate between west and east and south and north, all contribute. It may even be foolish to talk of the economic condition of British farming or of the British farmer, or to put forward sweeping proposals for the amelioration of present conditions without due regard for local, even parochial, conditions. Because of the immense importance of this aspect of British agriculture, an attempt is made in this

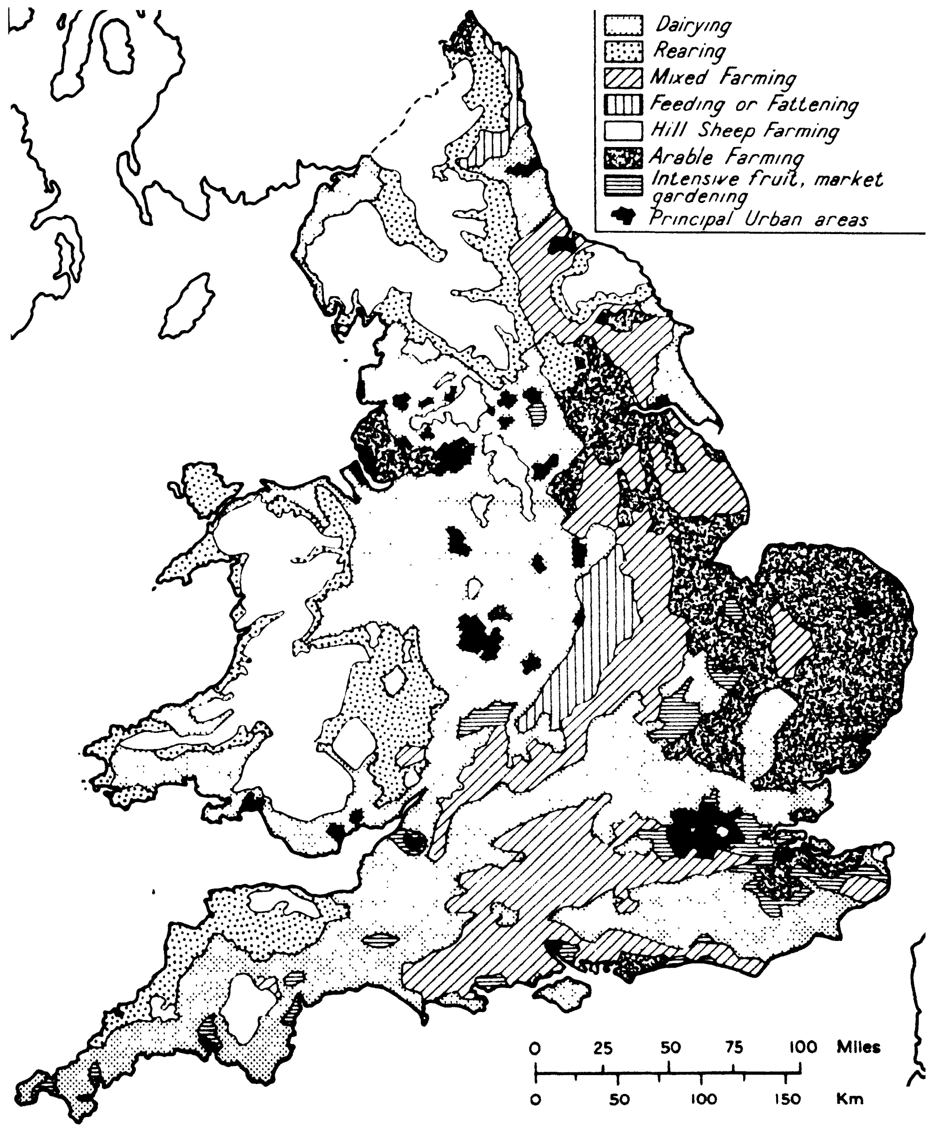



Fig. 103. Predominant types of farming in England and Wales

chapter to divide England and Wales into broad agricultural regions, and in some areas to suggest a tentative division into subregions. These agricultural regions show little or no relationship to administrative divisions, and statistics arranged on a county basis can be very misleading in forming comparisons. Even the unpublished parish statistics are frequently insufficient in detail, for a large proportion of English parishes owe their peculiar form, as in the long narrow parishes stretching from the North Downs to the heart of the Weald, to the necessity of sharing fairly between neighbouring parishes good and poor land, upland and lowland pasture suitable for sheep and cattle respectively, friable loamy land for tillage and heavy clay land unsuitable for crops. It was one of the main objectives of the Land Utilisation Survey of Britain to provide for the first time an exact record of the distribution of different types of use, by recording the use made of every field in Great Britain. In the County Reports an attempt was made to evaluate the relative importance of various physical factors, such as soil, elevation, aspect and drainage, as well as certain economic factors, in determining the type of farming in each area. Although the food production campaign of the 1939–45 war altered the proportion of arable and grass and pushed back the moorland fringe in places, the broad pattern of agricultural regions remains little changed.

The broad division into a Highland Zone in the north and west and a Lowland Zone in the south and east, which has already been used repeatedly, affords also a broad basis for dividing England and Wales into agricultural regions. The older rocks to the north and west, which give rise to comparatively poor siliceous soils, are on the whole upland regions which have a rainfall exceeding 760 millimetres (30 in) nearly everywhere. Soil and climate thus combine to render arable farming of secondary importance in nearly all areas. Where arable farming is undertaken, the range of crops which can be grown is limited and they serve mainly to provide winter feed for livestock. The land to the south and east, on the other hand, is underlain by younger and less resistant rocks and has soils more suitable for agriculture. Over the Midlands and eastern England the rainfall tends to be almost everywhere less than 760 millimetres (30 in), though most of the escarpments have a higher rainfall; and there is a broad distinction within the lowlands between the damper cattle-farming tracts of the west and the drier predominantly crop-farming tracts of the east.

In general, the cultivable and habitable tracts of the Highland Zone form tongues of varying size projecting into the great expanse of moorland and hill pastures: in the Lowland Zone, it is the infertile uplands which tend to form islands in a sea of cultivable and habitable land.

REGIONS OF THE HIGHLAND ZONE

## The Lake District or Cumbria

This region, consisting of a central knot of mountainous country with a very heavy rainfall and a surrounding fringe of lowlands (broken only in the southeast), exhibits considerable differences from an agricultural point of view; but because of the movement of animals (particularly sheep) from one part to another according to season, there is a certain essential unity in the whole region. Broadly it consists of four parts:

*The Central Mass* comprises rough hill pastures supporting fell sheep and valleys where dairy cattle graze. The uplands are the home of the Herdwick sheep and large tracts are common land. This area forms most of the Lake District National Park and is increasingly under heavy pressure for outdoor recreation.

*The Eden Valley*, on the lee side of the mountains, has a well-drained red soil and a lower rainfall which is as low as 760 millimetres (30 in) in places. As a result, there is a considerable proportion of arable land, but, owing to the northern situation, no wheat is grown, the leading crops being rotation grasses, turnips and swedes (grown for the fattening of sheep and cattle), oats and barley.

*The Solway Plain* has rather similar conditions and large numbers of fell sheep are fed in the winter months when the fell pastures are snow covered.

*The southwestern and southern fringes* consist of undulating land more exposed to rain-bearing winds, and hence with a heavier rainfall and less arable farming. There is much woodland and permanent grass, and cattle rearing takes a leading place.

## The Pennines

The easterly slope of the Pennine uplands is occupied by moorland or rough hill pasture. Considerable tracts, especially of the Millstone Grit areas of the central Pennines, are 'reserved' as water gathering grounds for the large towns on the flanks of the uplands (see Fig. 70), and here both animals and human inhabitants are few. Air pollution and recreational pressures from the surrounding towns provide additional handicaps to agriculture. North of the Aire Gap the Pennines are largely under hill sheep farms, and there are extensive tracts of common land; on the lower slopes sheep tend to share the pastures with beef cattle, which are sold to lowland farmers for fattening.

South of the tabular masses of sandstone which form the High Peak, the Pennines take on a very different aspect. This area is largely underlain by Carboniferous Limestone and soils are more fertile than elsewhere in the uplands; most of the land is under permanent grass and, despite its elevation, is devoted to dairy farming. The limestone scenery is attractive and the

area lies within the Peak District National Park and is under heavy recreational pressure.

## Wales and the Welsh Borderland

Agriculturally the Welsh massif consists of a core of moorland or rough hill pasture and a surrounding fringe of better agricultural land. The central core of rough hill pasture covers some 800 000 hectares (two million acres), about 200 000 hectares (half a million acres) of which are common grazings, out of a total for Wales of over two million hectares (five million acres). Much of the uplands is used for water gathering, large areas have been afforested since 1919, and recreational pressures are increasing, especially in Snowdonia. Almost the only tenants of the hill pastures are the sheep of the Welsh Mountain Breed.

The surrounding fringe may be divided as follows:

*Anglesey*, with its low surface and its rainfall averaging about 1000 millimetres (40 in), has remarkably little rough pasture, but a high proportion of permanent grass. This island was once the granary of Wales, but it is now largely devoted to grass or to barley and oats, all other crops being relatively unimportant. Until 1939 cattle farming for beef production rather than for milk was the leading occupation, though sheep were also numerous; but subsequently there has been a considerable expansion of dairy farming.

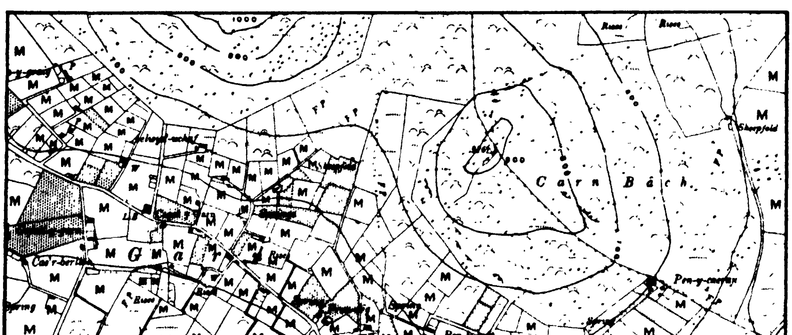


FIG. 104. A section of marginal hill land in North Wales

Typical of farming areas in the highland masses of the western part of Britain—innumerable tiny fields of which about 15 to 20 per cent are ploughed (shown by dotted areas), the remainder under grass (M), but which may be ploughed at intervals. All have been wrested with difficulty from the main mass of moorland, which will be seen to have re-invaded many of the enclosed areas. This is a section of one of the original field sheets of the Land Utilisation Survey (1932). The result of the war was to show much reclamation in land of this sort. Scale, 4 inches to 1 mile. (By permission of the Ordnance Survey and of the Land Utilisation Survey of Britain.)

*The valleys of North Wales and the Lleyn* are largely under grass, as might be expected from the heavy rainfall. On the arable land the leading cereals are

oats and barley, and, as everywhere in the west, wheat is unimportant, as are fodder root crops such as turnips, swedes and mangolds. These areas are, of course, cattle and sheep lands, and there is an important movement of sheep between the hill pastures in summer and the lowland pastures in winter.

*Southwestern Wales* includes the western two-thirds of Cardiganshire, the whole of Pembrokeshire and Carmarthenshire, and the small western portion of Glamorgan, and lies to the west of the great belt of upland rough grazings. Until 1939 these counties were for the most part under permanent grass and there was comparatively little ploughed land. In contrast with similar areas in Ireland, potatoes are of little importance, although south Pembrokeshire has risen to prominence in the post-Second World War period as an area for early potatoes. This is preeminently cattle country, with a large proportion of dairy cows, while sheep are now relatively unimportant. Farms accessible by good roads were quick to turn to dairy farming; those not accessible to the daily milk lorry are compelled to carry on mixed farming. During the Second World War, there was a great increase in ploughland, but this has now reverted to permanent pasture.

*The Vale of Glamorgan and Plain of Gwent* lie to the south of the moorlands of the South Wales coalfield. Although this tract lies within the boundaries of Wales, it is physically a detached portion of the Midlands and scarplands of England. The Vale of Glamorgan is an area of mixed farming, with dairying as the principal enterprise, but with large numbers of lambs also being fattened. To the east of the coalfield is the red land of Gwent in Monmouthshire.

*The Welsh Borderland* lies to the east of the main central mass of the Welsh mountain moorland or hill pastures. It stretches eastwards as far as the limit of the Welsh massif (which may be described as running north and south along the Malvern Hills) and is a varied area with broad valleys penetrating amongst the mountains. It includes, for example, the Vale of Powis, in which Welshpool and Montgomery are situated, but comprises also uplands such as those which occupy the southern half of Shropshire, Radnor Forest, and Clun Forest, as well as the rolling country which merges into the Plain of Gwent in the county of Monmouth. Two areas may be separately distinguished. One is the Forest of Dean (still largely forested) and the other is the Plain of Hereford. For the remainder, the hill areas are largely devoted to sheep, especially of breeds such as the Kerry Hill and Clun Forest, and to the rearing of beef cattle, while dairying is an important enterprise in the lowlands.

*The Plain of Hereford* is a varied lowland with rich red soils derived from the marls and cornstones of the Old Red Sandstone and the overlying drifts. It lies in the lee of the Welsh Uplands and most places have a rainfall of under 760 millimetres (30 in) a year. There is little mountain pasture, and although permanent grass is an important feature, the distinctive character of this tract is the considerable acreage under the plough. Barley, oats and

appreciable quantities of wheat are grown, as well as root crops, including sugar beet. The eastern part, like the neighbouring areas of Worcestershire, is well known for its hop gardens, the only other centre of importance outside the Weald. Fruit orchards, particularly of apples, occupy a large though diminishing area and Herefordshire is an important cider-producing county. Cattle, especially of the Hereford breed, and sheep are reared and fattened, although sheep are not as important as in most parts of the Welsh massif. The Plain of Hereford is a 'basin' amongst the hills and may sometimes form in winter a 'frost pocket' where cold, heavy and stagnant air tends to remain; in summer, fair warm conditions may prevail for longer periods than elsewhere.

## The southwestern peninsula

Although this is another area where old rocks tend to yield an indifferent soil, two features distinguish it agriculturally from other regions in the west of England. One is the plateau character of much of the surface which makes the land easily ploughed, though some areas are ill-drained; the other is the remarkable mildness of the winter which encourages certain crops to mature early. The higher lands of Exmoor and its outlier, the Quantock Hills, in the the north, and the granite masses of the south, particularly Dartmoor and Bodmin Moor, as well as Land's End and the Lizard area, are given over to rough hill pasture, much of it common land, on which sheep and some cattle are reared. On the improved land, permanent grass came to occupy a larger share than tilled land in the 1930s, but the southwest, and Cornwall especially, was remarkable for the large amount of land remaining under the plough. The plough-up campaign of 1939 44 produced a great change in Cornwall and to a less extent in Devon, and the practice of taking the plough round the farm led to nearly all land being ploughed in some areas; since 1945 much of this land has been laid down again to grass. Certain of the drier tracts with more favourable soil conditions favour the production of limited quantities of wheat, and barley has become the dominant grain crop; formerly, the southwest was distinguished by the prominent place occupied by mixed corn, a mixture of barley and wheat. Most of the ploughed land is occupied by fodder crops which tend to emphasise the great importance of cattle-rearing and dairy-farming. Formerly the emphasis was on butter, cheese and cream rather than on milk, since the southwestern peninsula long remained too inaccessible from the great centres of milk consumption for fresh milk to be a first consideration. But for direct supply of milk to factories the position is different, and Nestlé's and other firms established collecting stations in the area. Since the creation of the Milk Marketing Board, an increasing volume of milk for liquid consumption has been produced in the southwest. The western half of Cornwall is remarkable for the high density of the pig population, a legacy of the once-abundant supply of skim milk on farms; large

numbers of store pigs are sent eastward for fattening. The mildness of the sheltered valleys, especially around Penzance and north of Plymouth, is reflected in the large output of early flowers, potatoes and vegetables, for example, winter cauliflower or broccoli.

## TRANSITIONAL REGIONS

### Northumbria

This region, which may alternatively be described as northeastern England, occupies the eastern halves of the counties of Northumberland and Durham and a portion of the North Riding of Yorkshire. Broadly, there are two parts: (*a*) the gentle eastern slope of the Pennines and the undulating country between the Pennines and the sea in Northumberland and the northern part of county Durham, and (*b*) the lower Tees basin. The first is a region of indifferent, rather heavy soils, and the proportion of arable land to permanent grass steadily increases as one gets on to lower ground towards the coast. Durham is world famous for its Shorthorn cattle or 'Durhams', but the crops which can be grown are those which do not have exacting requirements. There is very little wheat, for example, and root crops are comparatively unimportant. Near the Scottish border, however, the richer land supports a considerable production of barley, turnips and swedes. Elsewhere the emphasis is on fodder crops, reflecting the importance of cattle-rearing and sheep-breeding. Lowland Northumberland is also an important area for fattening cattle. On the lighter drift soils of the lower Tees basin and in the Magnesian Limestone belt of east Durham conditions are much more favourable for arable farming. Wheat, barley, oats, potatoes, turnips and swedes are grown, and there are large tracts under fodder grasses.

### The eastern slopes of the Pennines in Yorkshire and Derbyshire and the Nottinghamshire border

This region is terminated eastwards by the fertile Vale of York. Its agricultural conditions generally resemble those in Northumbria. Spurs of moorland separate the fertile and attractive Yorkshire dales of the Swale, Ure, Nidd, and Wharfe, but farther south in the drainage basins of the Aire and Don, agricultural utilisation is overshadowed by industrial development.

In the western parts of the coalfield there is a long tradition of small holdings, many of them occupied by retired industrial workers. Small dairy farms, dependent largely on purchased feedingstuffs, are still characteristic of this area. Pigs and poultry are also present in large numbers. The unique

rhubarb-growing area south of Leeds is on largely manmade soil; the underlying Coal Measures otherwise give rise to heavy acid soils.

## REGIONS OF THE LOWLAND ZONES

### The Plain of Lancastria

Geographically and agriculturally the Plain of Lancastria comprises the western half of Lancashire, that is west of the moorland, practically the whole of Cheshire, the detached portion of Flintshire, and the northern half of Shropshire, including the area round Shrewsbury, although the industrial development of south Lancashire has tended to obscure the very great importance of that county from the agricultural standpoint. Practically the whole area is lowland, with a rainfall varying between 635 and 760 millimetres (25 and 30 in), and is underlain by the red rocks of the Triassic period. The soils derived from the Upper Series, the Keuper Marls, are comparatively heavy, and thus differ from the light soils derived from the Lower Series, the Bunter Sands. However, the greater part of the plain has been covered with glacial drift, and it is the character of these drift deposits which largely determines local agriculture. In some areas, especially near the hills, heavy boulder clay is found; such land is unsuitable for cultivation and hence is devoted in the main to permanent pasture. Where the soils are lighter and more loamy, arable farming becomes important, and there are intensively farmed areas of reclaimed peatland.

Three main areas may be distinguished in the Plain of Lancastria:

*Lowland Lancashire* north of the Ribble basin, including the Fylde district, is an area where heavy soils prevail and are mainly under permanent grass. This is an important dairying region with a very large number of dairy cattle, pigs, and remarkably high densities of poultry. A large proportion of its products is destined for the industrial towns of the southern half of Lancashire. In addition large numbers of sheep from the neighbouring moorlands are pastured, especially in winter.

*Southwestern Lancashire and the Mersey valley* are almost entirely under arable crops. It is almost the only area in the west of England where wheat is an important crop, but the distinctive crops are potatoes and vegetables, while pigs and poultry are relatively important.

*Cheshire and North Shropshire*, where the heavy soils are mainly under grass, although large acreages were ploughed during the Second World War. It is preeminently a dairy-farming region, with the highest density of dairy cattle in Great Britain. The farms are small, often run by the farmer and his family, who, under pre-1939 conditions, often sold milk in the winter when prices were good, and made cheese in summer. Little farmhouse cheese is now made and most milk goes for liquid consumption. Pigs and poultry are both numerous.

## The Vale of York

This is in the main a tract of glacial drift, lake silts, and alluvium. It was formerly marshy, but is now well-drained and mainly fertile land. There is much land under pasture, but this may be described as one of the northernmost arable areas of any importance in England. It is certainly the northernmost area where wheat is a crop of significance and large quantities of barley and oats are also grown. The deep fertile soils favour root crops, notably potatoes, turnips, swedes, mangolds and sugar beet, with carrots on very light land. Around the head of the Humber large acreages of vegetables are grown. Cattle-fattening is also important.

## The Midlands of England

It is by no means simple to give a general account of the agriculture of the large triangle in the heart of England to which this name of the Midlands has been applied. It lies east of the Welsh massif, south of the Pennines, and is bounded on the southeast by the first of the major scarps of the Jurassic rocks which cross England. The southeastern boundary thus defined does not coincide with any one geological horizon, but with a physical feature which, though discontinuous, can be well seen on the ground. The large

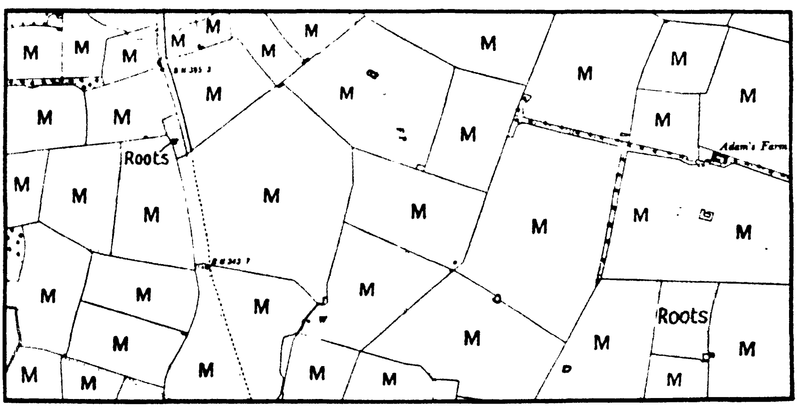



FIG. 105. A section of country in the Midlands of England in 1932

Typical of farming economy in the damp Midland plains or the clay vales. The land is evenly divided into moderate sized fields, which before 1939 were nearly all under permanent grass, with a small field here and there devoted to root crops for winter feed. Scale, 4 inches to 1 mile (By permission of the Ordnance Survey and of the Land Utilisation Survey of Britain.)

During the plough-up campaign of the Second World War, country of this type showed a greater change than anywhere in Britain and as much as 50 per cent was ploughed

triangle so delineated includes the southern two-thirds of Staffordshire, practically the whole of the county of Warwick, most of Worcestershire, and extends southwestwards to the Vale of Evesham and the Vale of Gloucester, which lies between the Welsh hills and the scarp of the Cotswolds. To the northeast it includes the whole of Leicestershire and a portion of western

Rutland, as well as the borders of Northamptonshire, the greater part of Nottinghamshire and the western fringe of Lincoln as far east as the scarp of Lincoln Edge. In general terms this is an undulating plain with rather heavy clayey or marly soils derived for the most part from the Keuper Marls and from the clays of the lower part of the Jurassic series (especially the Lias) or, more frequently, from the glacial drifts of local material. Much of the east Midlands is excellent grazing land, and was largely under permanent pasture before 1939. In the Middle Ages it is clear that considerable areas were ploughed and many fields show the well-known ridge and furrow indicative of early attempts to drain heavy soils. During the Second World War there were great changes. Mechanisation made it possible to plough the stiff soils with comparative ease and some very heavy crops, notably of wheat, resulted; but much of this land has since been put back to grass. The heavy soils of the Midland plain are interrupted over considerable areas by tracts of lighter soils. The Keuper Sandstones afford some excellent loams and so do some of the sandy drifts. There are also areas where the Bunter Pebble Beds and Sandstone outcrop and where the soils are light; much of this ground is rather infertile and is still covered with woodland, as, for example, in Sherwood Forest in Nottinghamshire, and in Cannock Chase. There are also hilly or upland areas formed by the outcrop of old rocks, as in Charnwood Forest. In the east, there is a tract of country, occupying roughly the eastern half of Leicestershire, which is intermediate in character between the Midland lowlands and the hills of the scarplands, and in this area there is more arable farming. Lying just to the south on the borders of Northamptonshire is one of the best known centres for cattle fattening in England. These famous fattening pastures of the Melton Mowbray–Market Harborough district are excellent and will fatten one bullock and one sheep on 0.4 hectare (one acre). The cattle and sheep are purchased from March onwards and sold for killing from July onwards. In the southwest in the Vale of Evesham and in parts of Worcestershire soil conditions favour extensive orchards, especially of plums and apples, with which vegetable growing is closely associated. This is one of the principal horticultural areas in Great Britain and is distinguished by the large numbers of small holdings.

## Northeast and east Yorkshire

The eastern part of the North Riding and most of the East Riding of Yorkshire fall clearly into four agricultural divisions:

*The Cleveland Hills and the North York Moors* form a plateau dissected by deep valleys, with rough hill pastures and heather moors occupying the higher parts of the hills; in the valleys there are considerable areas of pasture, but despite a location on the drier eastern side of Great Britain, there is little cultivation largely owing to the prevalence of steep slopes and to the risk of

flooding on the low ground. A belt of arable land coincides with the Corallian 'tabular hills'.
*The Vale of Pickering* was once occupied by a lake, but now consists of well-drained arable land reminiscent of the Fenland. The position of the villages on the margin is worthy of note; from them the central area is farmed.
*The Yorkshire Wolds* stretch in the form of a broad crescent from the Humber to Flamborough Head. The tops of these hills are almost bare chalk, but the dipslope in the east is covered with varying thicknesses of chalky boulder clay. Thanks to some early and farseeing enclosure initiated by the Sykes family, the Wolds are devoted to arable crops and it says much for the farmers that they can successfully cultivate such thin soil. Farms are large, barley, turnips and swedes and rotation grass are the principal crops, and sheep and beef cattle are fattened. Around Hull, vegetables are grown, the original impetus coming from Dutch immigrants in the 1930s.
*Holderness.* This lowland, covered with deep boulder clay and patches of sand and gravel, has been drained with some difficulty and is mainly cultivated. Wheat is the chief crop and fat cattle, sheep and pigs are the main livestock products.

## Lincolnshire

The Lindsey Division of Lincolnshire repeats the conditions found in the East Riding of Yorkshire. The Trent Vale in the west of the county is part of the Midlands and has the damp cattle pastures already described, although there are considerable areas under cultivation. Lincoln Heath, on the dip slope of the Lincoln Edge scarp, is largely under tillage crops, notably barley, and the lowland which separates the Heath from the Lincolnshire Wolds is an area of mixed farming. The Lincolnshire Wolds repeat many of the features of the Yorkshire Wolds, and the Lincolnshire Marshes are important cattle fattening areas.

## The scarplands and clay vales

Stretching across England from the neighbourhood of Lincoln to the Dorset coast, there is a series of discontinuous, westfacing scarps, accompanied by long, gentle dipslopes (cf. pp. 46–50). The uplands are mainly of limestones, calcareous grits or sandstones, and the well drained higher levels are mainly given over to arable land. Barley and rotation grass are the chief crops, although vegetable-growing has extended to the Cotswolds from the Vale of Evesham. This is a land of large farms and mellow stone villages. The dip slopes merge gradually into the great clay vale, which may be said to extend as far as the chalk scarp and from the borders of the Fens on the northeast to the Dorset–Devon coast on the southwest, although south of Bath the valley is ill-defined. In places the main vale is interrupted by low ridges where harder rocks outcrop, but it is mainly a low-lying belt

of clay which gives rise to heavy soils. Permanent pasture and cattle-rearing are the keynotes throughout the greater part of the area, although there is now more ploughed land than there was before the Second World War. This description applies to much of the county of Northampton (except the mainly arable ironstone belt with its rich red soils), the northern half of Buckinghamshire, the central tract of Oxfordshire and the northwestern part of Wiltshire. The belt extends into the eastern and southern parts of Somerset and the neighbouring parts of Dorset and Devonshire. It is from these parts of Wiltshire, Somerset, and the borders of Dorset that much of London's milk is obtained, for it is preeminently dairy-farming country. The production of bacon and sausages are important subsidiary industries. In the northeast where the great clay vale abuts on the Fenland, there are large tracts covered with glacial deposits, particularly chalky boulder clay, which afford excellent mixed soils; as a result, large areas in Huntingdonshire and the southern part of Cambridgeshire and Bedfordshire are arable land. Where heavy boulder clay occurs the land is poorer, notably in the western half of Huntingdonshire. Where light loams result from the outcrop of Lower Cretaceous sands or from the occurrence of terrace gravels there are the market gardening areas around Sandy and Biggleswade in south Bedfordshire. This, too, is an area of small holdings, which formerly depended on supplies of London manure to maintain the fertility of its light soils.

## The Fenlands

The once watery waste known as the Fens has now been almost completely drained, the great work of reclamation having begun in the seventeenth century with the help of Dutch engineers. Both the dark-coloured mild peat soils of the drained fens and the silts of land reclaimed from the Wash are very fertile, although the peats are gradually disappearing through bacterial action and wastage, and parts of these lands already lie below sea-level. This is undoubtedly the most intensively cultivated arable area in the British Isles and yields of most crops are higher than elsewhere. It comprises the Holland Division of Lincolnshire and the Isle of Ely, together with the neighbouring parts of Lindsey and Kesteven and the fringes of Norfolk. More than three-quarters of the whole area is under the plough and amongst the great variety of crops grown are large quantities of wheat and sugar beet. Special mention must be made of potatoes, since this is the greatest area of potato cultivation in the British Isles. Large acreages on the silts are under vegetables and bulb flowers, the latter especially in the tulip fields near Spalding, and the area around Wisbech produces top fruit and small fruit, especially strawberries. Vegetables are also grown on the peats, notably celery around Littleport. Farms are generally small and few livestock are kept. The limited areas of pasture are found especially on the

'islands' of boulder clay (see Fig. 106) or on the 'washlands' between the main drainage channels.

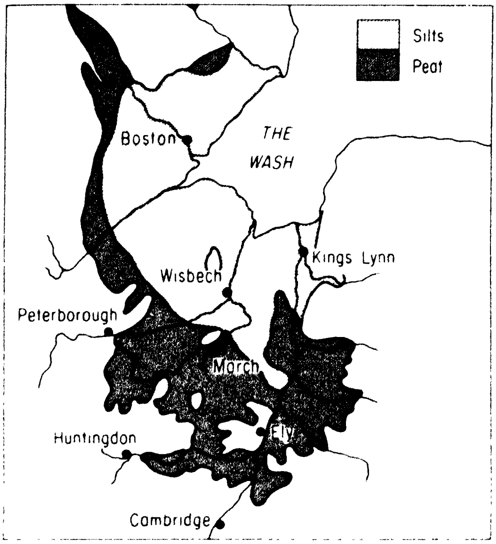



FIG. 106. The Fenlands
Unshaded areas are largely of boulder clay. Notice the boulder clay 'islands'

## The Plain of Somerset

The Plain of Somerset, between the Mendips and the Blackdown Hills, is very different. Lying on the wetter side of England, it has not been so adequately drained and is therefore still occupied by wet pastures; parts are liable to almost annual floods. The Somerset Levels, though also underlain by peat, are largely devoted to dairy cattle. During the winter there is flooding and cattle are kept on surrounding higher land. The Levels are also handicapped by highly fragmented farms. However, there is good arable land in the Vale of Taunton and the little Vale of Porlock, and store cattle and pigs are fattened.

## The Chalk lands of the southeast

The Chalk lands comprise the North and South Downs, the open downs of Dorset, Wiltshire and the northern part of Hampshire, and the stretch of Chalk country forming the Chilterns and continuing northwards as the East Anglian Heights. Farther to the northeast the Chalk occurs over wide areas in East Anglia, but it is so masked by glacial deposits that the land is entirely different in character. At least four types of land are found along

the Chalk outcrop. The main downland areas, where there are few superficial deposits, are largely under arable cultivation. Farms are large and barley and rotation grass the chief crops, the latter often used for the support of dairy cattle or for the fattening of beef animals. Where the land is not sufficiently good for ploughing or where the elevation is perhaps too great, the Chalk was formerly covered by pastures traditionally used for sheep rearing. In the old days the sheep fed by day on the grass, and at night were folded on the fallow arable land which they enriched with their manure.

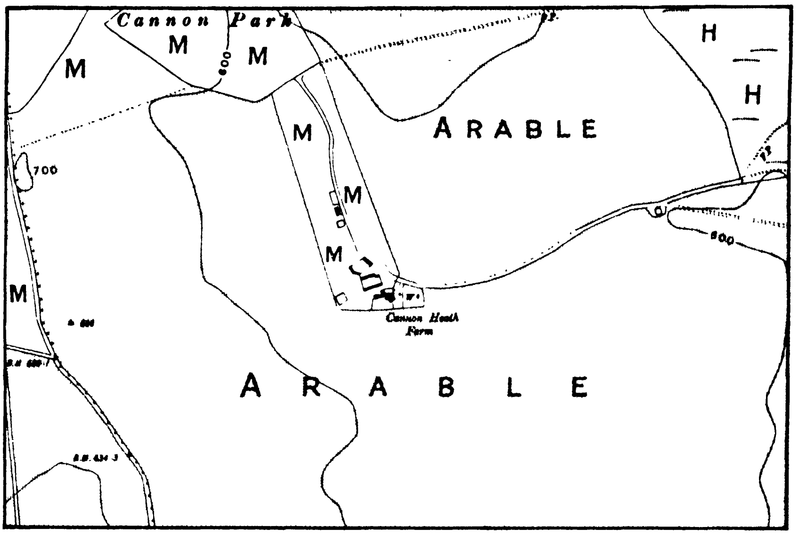



FIG. 107. A section of country on the 'downlands' of southeastern England with huge open stretches of ploughed land, limited areas under pasture (M), and the poorer land left as rough pasture (H) for sheep. Scale, 4 inches to 1 mile
(By permission of the Ordnance Survey and of the Land Utilisation Survey of Britain)

Later root crops were grown on the fallow for the sheep. Each region of the Chalk lands evolved its own type of sheep, such as the South Downs. High labour costs and artificial fertilisers have made sheep-farming less attractive and less necessary and sheep are no longer characteristic of such areas. Where there is a coating of gravel, the Chalk lands are often not used for agriculture or are under rough pasture, and land of this character has been utilised for the military training grounds of Salisbury Plain. In other areas, like the Chilterns, the surface of the Chalk is covered by a residual deposit known as Clay-with-flints. This tenacious brown clay, from which the lime has been almost entirely leached away, gives rise to stony soils, so that it is difficult to grow crops other than grass and cereals; much of this land is in mixed farming, with dairy cattle as the major enterprise.

## East Anglia

East Anglia, comprising the greater parts of the counties of Norfolk and Suffolk, as well as the northern two-thirds of Essex, may be broadly described as a low plateau. Chalk underlies a great deal of the area, but its characteristic feature is the wide mantle of glacial deposits. The surface utilisation and the type of farming largely depend upon the characters of these glacial deposits (see Fig. 108). The central belt is occupied by mixed

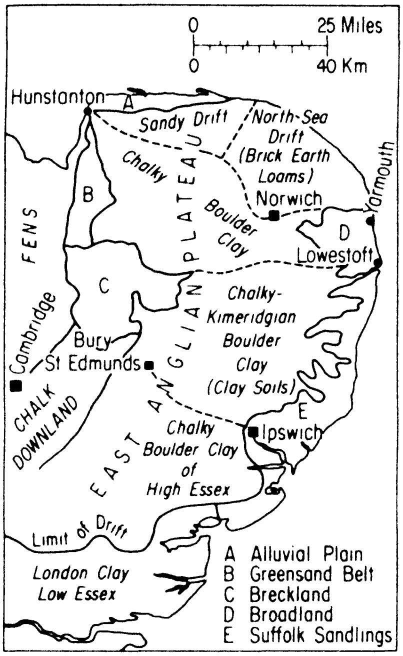



FIG. 108. East Anglia

Agricultural regions (based on those suggested by Professor P. M. Roxby), with the East Anglian plateau subdivided according to the character of the boulder clay (after maps by the late F. W. Harmer).

loamy soils and is excellent arable country. Nearly half the arable land is under cereals; farmers on the lighter soils grow barley, on the heavier wheat, but sugar beet and field crops of vegetables, such as peas for canning and quick freezing, are also important. Blackcurrants are also a distinctive crop, especially in northeast Norfolk, and the acreage under top fruit in East Anglia has been increasing steadily since the Second World War. Formerly sheep were fed on swedes, and big Irish Shorthorn bullocks fattened for Christmas. Now sugar beet tops are used; grass-fed lambs are important, while young bullocks are winter fed on kale and fattened on grass in summer. Broiler production of turkeys is increasingly important. In

the west coarse sands occur over the huge tract known as Breckland, which is largely afforested with conifers planted by the Forestry Commission, and a similar tract, the Suffolk Sandlings, occurs near the coast in the east; a post-1945 revolution has been the conversion of these light lands to fertile arable by new techniques. East of Norwich are the Broads, stretches of shallow water now known to occupy old peat workings. On some of the heavier soils dairying became important, but is now declining in favour of more profitable enterprises. The southern limit of the area coincides with the limit of the chalky boulder clay; farther south are heavy lands on London Clay.

## The London Basin

Although a comparatively small area, the London Basin is remarkably complex. At least four major types of land must be distinguished:

*London Clay* gives rise to heavy soils which were formerly under permanent pasture, much of it providing hay for London horses. It is now (where not built over) largely under the plough, especially in Essex where vegetables and soft fruit are distinctive crops. Many areas are still extensively wooded, e.g. Epping Forest which was for many centuries a royal hunting ground.
*Sandy areas*, more especially the great Bagshot Sand plateau towards the west of the basin, have extremely infertile coarse sandy soils and are largely occupied by heathland and pine woods, although nursery gardens are important in some areas.
*Belts of mixed soils*, usually excellent loams, are particularly conspicuous along the southern margin of the basin in north Kent. This is the great market gardening and fruit farming belt of Kent, supplying large quantities of fruit and vegetables to the metropolis.
*Stretches of brick-earth*, terrace gravel, and alluvium occur in the Thames Valley at different levels. The high-level gravels may be overdrained and infertile, but the lower terraces, for example over much of Middlesex, afford excellent soils for market gardening and fruit. Unfortunately, much of this land has been taken for housing or other development and little remains in cultivation.

## The Hampshire Basin

In many respects the Hampshire Basin repeats the features seen in the London Basin, although clay lands are less and sandy areas are more important. There are heavy clay areas largely occupied by permanent pasture, a belt of mixed soils, largely under arable crops (and including the specialised strawberry growing around Swanwick), the large tracts of barren sandy soil, occupied in particular by the New Forest, and belts of gravel or alluvium. It should be noticed that both in the Hampshire and London

Basins, as well as in the neighbouring parts of the chalk lands and in the Wealden belt, agricultural use depends very largely on economic conditions and the requirements of the metropolis. Much of this area is thus in semi-agricultural use for part-time or hobby farming.

## The Weald

The Weald is the region between the North and South Downs. In the heart is a sandy area occupied largely by Ashdown Forest and tracts of heathland, although the sandstones are very fine grained and fruit growing is important. Towards the margins of the Weald are the sandy ridges of the Lower Greensand which vary greatly in character, from the fruit-growing areas around Maidstone to the extensive heaths and coniferous woodlands between Dorking and Petersfield. Much of the rest of the Weald is occupied by the Weald Clay and other clay beds, which give rise to damp country which was formerly covered with oakwood, but is now cleared and occupied by pasture supporting numerous cattle. Round the fringes of the Weald is a narrow lowland called Holmesdale which coincides with the outcrop of the Gault; on the better drained margins there is a belt of mixed soils very suitable for cultivation. It is on some of the better soils that the hop gardens and orchards for which Kent is well known are found. A small but important region within the Weald is Romney Marsh, now largely drained and carrying the highest densities of sheep in the British Isles. In summer some tracts of this rich pasture land carry and fatten six or eight sheep and lambs per acre, but in winter only the breeding ewes remain. It has now been found that the soils are as suitable for intensive cultivation as those of the Fenland. In contrast are Pevensey Levels which are largely devoted to pasture for cattle.

# 13
# The British fisheries[1]

The post-Second World War period has witnessed a marked upsurge in world landings of fish. This state of affairs, however, has not been evident in the British fishing industry and figures for both employment and landings were in the late 1960s at their lowest levels in modern times. Over the period 1948 to 1967, in which world landings (measured by live weight) increased from 19.6 million metric tons to 60.7 million metric tons, the corresponding figures for the United Kingdom have been 1.2 million metric tons and 1.0 million metric tons.

No western European nation has matched the spectacular postwar growth of fishing that has occurred in Peru, Japan, China and the USSR, but most have had some increase in landings and the Norwegian catch, the largest in Europe, increased from 1.4 million metric tons in 1948 to 3.2 million metric tons in 1967.

In terms of weight of landings, the United Kingdom is thirteenth in the world but, when value is considered, the position is more favourable and the placing is sixth among nations that publish values (i.e. excluding China and the USSR where landings are obviously more significant). British catches contain a good proportion of high value fish whereas some countries concentrate on industrial fishing (i.e. catching fish largely for low value outlets such as meal and oil plants). The prime example of an industrial fishing nation is Peru, where the world's largest catch of over 10 million metric tons (one-sixth of the world total) was landed in 1967. The fish are anchovies which are mainly converted into meal and their value, $117 million, was only two-thirds that of the much smaller United Kingdom catch.

The total value of United Kingdom landings of fish in 1967 was £64 million. Freshwater fisheries, mainly for salmon, contributed just under £3 million to this figure and, although these fisheries may have considerable local significance, particularly on the rivers of the east of Scotland, their overall importance is obviously small and this chapter will concentrate on the sea fishing industry.

Three general categories of fish are normally recognised: demersal fish

1. This chapter has been rewritten by Dr T. D. Kennea, to whom I am much indebted. Dr Kennea also compiled the two maps, Figs 109 and 110.

such as cod, haddock and flat fish, which spend much of their lives on or near the sea bed, pelagic fish such as herrings, mackerel and sprats which are considered as near-surface dwellers, although they usually have demersal phases, and shellfish. It is upon the first of these groups that the British fishing industry is mainly dependent and, in 1967, it comprised 88 per cent by value and 78.6 per cent by weight of the total United Kingdom catch. The corresponding figures for pelagic fish were 5.4 per cent and 16.7 per cent respectively and for shellfish 6.6 per cent and 4.7 per cent respectively.

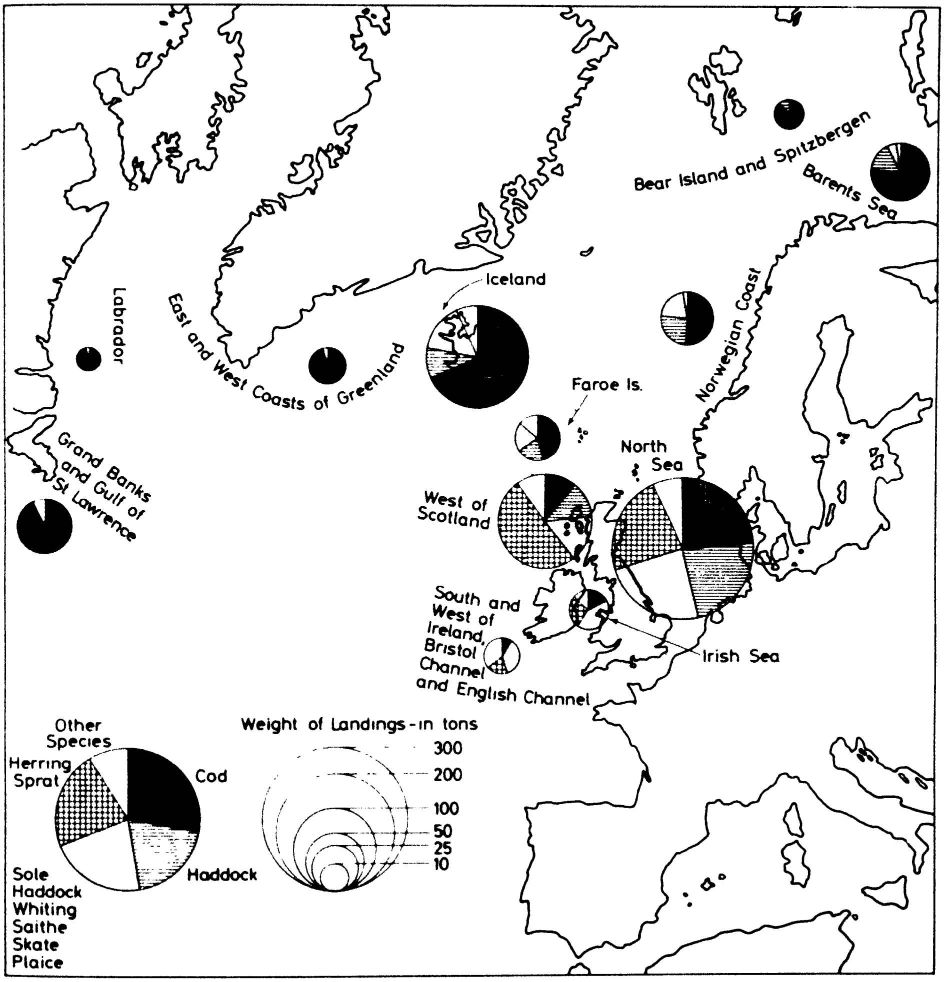



FIG. 109. The main fishing grounds used by British fishermen, and their yields in 1967

It is clear that pelagic fish have a lower value per unit weight than other types. They do not keep as well as most demersal species and many are processed in some form or another. The herring is the most important

pelagic fish and its partial disappearance from the North Sea is the principal reason for the considerable drop in pelagic landings (see Table below).

At present, there is rather greater emphasis on pelagic fish in Scotland than in England and Wales and in the heyday of the herring fishery, when biggest catches were in English waters, a high proportion of the landings were made by Scottish drifters which travelled around the coast fishing, in the appropriate seasons, where the shoals were densest.

The Scottish demersal landings have been higher in the 1960s than at any time in the past and this has, to some extent, helped to counteract the postwar decline in the more important English and Welsh catch. These changes will be considered in greater detail later in the chapter.

Landings in Northern Ireland have been small and, in 1967, amounted to 9 100 metric tons (9 000 long tons), which fetched £470 000 at first sale; shellfish accounted for more than half the total value.

*Landings ('000 tons) of wet fish in Great Britain*

| | | ENGLAND AND WALES | | | SCOTLAND | | | GREAT BRITAIN | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | DEMERSAL FISH | PELAGIC FISH | TOTAL | DEMERSAL FISH | PELAGIC FISH | TOTAL | DEMERSAL FISH | PELAGIC FISH | TOTAL |
| 1913 | long | 418 | 389 | 807 | 137 | 227 | 364 | 555 | 616 | 1171 |
| | metric | 425 | 395 | 820 | 139 | 231 | 370 | 564 | 626 | 1190 |
| 1919 | long | 319 | 196 | 515 | 107 | 192 | 299 | 426 | 388 | 814 |
| | metric | 324 | 199 | 523 | 109 | 195 | 304 | 433 | 394 | 827 |
| 1930 | long | 573 | 211 | 784 | 135 | 175 | 310 | 708 | 386 | 1094 |
| | metric | 582 | 214 | 802 | 137 | 178 | 315 | 719 | 392 | 1112 |
| 1938 | long | 632 | 145 | 777 | 125 | 144 | 269 | 757 | 289 | 1046 |
| | metric | 642 | 147 | 789 | 127 | 146 | 273 | 769 | 294 | 1063 |
| 1949 | long | 629 | 80 | 709 | 158 | 135 | 293 | 787 | 215 | 1002 |
| | metric | 639 | 81 | 720 | 160 | 137 | 297 | 800 | 218 | 1018 |
| 1959 | long | 516 | 31 | 547 | 185 | 111 | 296 | 701 | 142 | 843 |
| | metric | 524 | 31·5 | 556 | 188 | 113 | 300 | 712 | 144 | 856 |
| 1967 | long | 482 | 33 | 515 | 213 | 114 | 327 | 695 | 147 | 842 |
| | metric | 490 | 33·5 | 523 | 216 | 116 | 332 | 706 | 149 | 855 |

Sources: *Sea Fisheries Statistical Tables*; *Annual Reports of the Fishery Board for Scotland*; *Scottish Sea Fisheries Statistical Tables*.

To a considerable extent, fishing techniques vary according to the type of catch it is hoped to make. About 80 per cent of demersal fish are taken by trawling, a method by which a very large net bag is towed along the seabed catching the fish in its path. The front of the bag is kept open, in the vertical, by weights on the lower part of the mouth and floats along the top and, horizontally, by the pressure of water against 'otter' boards attached to the towing lines and acting as kites. Trawling takes place to a maximum depth of about 250 fathoms.

Most of the remaining 20 per cent of demersal fish is caught by Danish seining. The method was introduced to the British Isles in 1921 and has been employed principally by Scottish fishermen. It is a system of netting in some ways not unlike trawling, that is particularly suitable for use by medium size vessels fishing on smooth grounds; it accounts for nearly 50

per cent of Scottish demersal landings. Only about 1 per cent of demersal fish are taken by line fishing, which was once a method of some considerable importance.

Trawling is also responsible for the largest share of the catch of pelagic fish (over 50 per cent in 1969). The methods are somewhat different from trawling for demersal species and there are nets that may be operated in midwater, frequently by two vessels, one towing on each side of the instrument; for obvious reasons, this is known as pair trawling. The system was introduced from Scandinavia after the Second World War and is now the principal method by which sprats are taken. About 40 per cent of British landings of herring are also caught by trawling; pair trawls are sometimes used but a modified type of bottom trawl is more important. The fish are

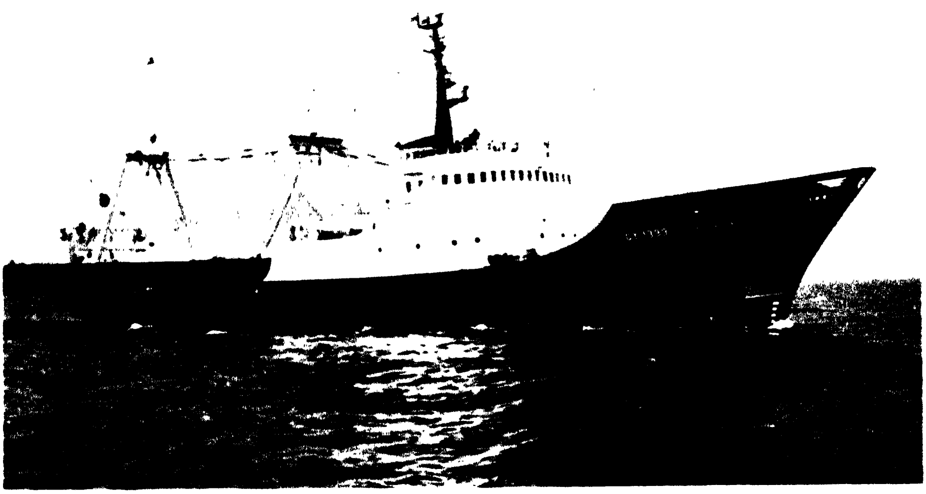


PLATE 7. A modern Grimsby trawler

usually taken in daylight when they are near the seabed. In the evening they move towards the surface and it is then they become enmeshed in drift nets which are, effectively, curtains of netting suspended in the water; each boat may have a fleet of these nets extending for several miles. Drifting, which now accounts for less than 20 per cent of herrings landed, has declined markedly, and even in 1967 was responsible for 40 per cent of the catch; it is a high-cost, comparatively inefficient system, requiring many expensive nets and a large complement of men for each vessel. The remaining 40 per cent of the herring catch is taken by ring nets and purse seines, mainly in the more sheltered of Scottish waters; the fish are trapped by a wall of netting laid around the shoal in a roughly circular form.

Finally, line fishing may be mentioned as the principal method of catch-

ing mackerel. The lines are either towed behind a moving boat or lowered into a shoal of fish and immediately pulled up again, often with a fish on each of up to about fifteen hooks. Feathers are most frequently used as bait although other light coloured or shiny material may be employed.

Shellfish are taken in many ways. Lobsters and crabs are caught in baited traps, so also are crawfish though many of these, which are only of any significance to British fishermen in Cornish waters, are captured by skindivers. Oysters and escallops are dredged up, and Norway lobsters, known commercially as scampi, are trawled. Other shellfish fall to methods probably more numerous than the kinds of fish and including suction dredging for cockles and hand gathering and netting of several types.

In terms of total number of vessels, small boats play a large part in the British fishing industry (out of some 6000 fishing vessels, over 4000 are less than 12 metres (40 ft) in length) and although some trawlers regularly fish far afield, the North Sea is still the most important single fishing area, providing about one-third of the total catch (Fig. 109). Nevertheless, the relatively small number of ships in the distant water category (only 182 vessels of over 42.59 metres (140 ft) length), operating over widely separated areas of the northern hemisphere, land about 40 per cent of the demersal fish.

*British landings of fresh and frozen demersal fish by main vessel length groups in 1967*

| VESSEL LENGTH GROUP | | QUANTITY '000 TONS METRIC | LONG |
|---|---|---|---|
| Over 42.5 m (140 ft) | England and Wales | 311.3 | 306.4 |
| | Scotland | 1.6 | 1.6 |
| 24 m to 42.3 m (80 ft- 139.9 ft) | England and Wales | 126.0 | 124.6 |
| | Scotland | 86.3 | 84.9 |
| Under 24 m (80 ft) | England and Wales | 50.7 | 49.9 |
| | Scotland | 128.9 | 126.9 |
| | Northern Ireland | 5.5 | 5.5 |
| All vessels | England and Wales | 488.6 | 480.9 |
| | Scotland | 216.8 | 213.4 |
| | Northern Ireland | 5.5 | 5.5 |

Source: *Sea Fisheries Statistical Tables.*

The distant grounds are also more productive than those nearer, although the difference is less significant than it appears from the Table on p. 259. The larger craft fishing the remote areas are more powerful, use bigger nets and have a greater catching capacity than smaller boats. Also, as the distant water vessels spend much of each voyage steaming to and from the grounds, they need a higher catch rate as compensation. Neverthe-

less, the relatively small number of ships in the distant water category (only 161 are vessels over 42.59 metres (140 ft) in length), operating over widely separated areas of the northern hemisphere, land nearly 50 per cent of the demersal fish.

Important though the distant areas are, the reliance of much of the British fishing industry upon less productive near waters cannot be escaped. Parts of this section are doing well, but others continue in operation, with the help of subsidies, on grounds only marginally profitable; as there is no evidence, however, of a spur of strong consumer demand, greater diversion of effort to the deep sea sources is not justified. On the other hand, countries such as the Soviet Union and Japan, with a large market for fish and determined to expand their industry in the postwar period, have built vessels able to fish as far afield as the South Atlantic, and with facilities for freezing and processing the entire catch on board.

*Catch of demersal fish per hour fishing time by vessels of 12 metres (40 ft) and over on principal grounds in 1967*

| | CWT | KG |
|---|---|---|
| Barents Sea | 12.1 | 614.7 |
| Norwegian Coast | 12.1 | 614.7 |
| Bear Island and Spitzbergen | 13.8 | 701.0 |
| North Sea | 2.0 | 101.6 |
| Iceland | 9.7 | 492.8 |
| Faroes | 7.2 | 365.8 |
| West of Scotland | 4.3 | 218.4 |
| Irish Sea | 1.4 | 71.1 |
| English Channel | 0.7 | 35.5 |
| Bristol Channel | 1.5 | 76.2 |
| East and West Coast of Greenland | 26.3 | 1335.0 |
| Labrador | 32.1 | 1630.7 |
| Grand Banks | 17.8 | 904.3 |
| Gulf of St Lawrence | 20.8 | 1056.7 |

Source: Derived from *Sea Fisheries Statistical Tables*.

At the end of 1969, out of a British distant water fleet of 161 craft, there were six such trawlers, another twenty-seven able to freeze their catch and one with facility for part-freezing. On 31 December 1965 there had been twelve of these vessels, and during that year their landings totalled 31 500 metric tons (31 000 long tons). The corresponding figure of 96 500 metric tons (95 000 long tons) for 1969 represented nearly 30 per cent of the distant water catch. Over the same period conventional distant water trawlers decreased in importance (their numbers declined from 184 at the

end of 1965 to 127 at the end of 1969) although the vessels going out of service were the least efficient.

Freezer trawlers may stay away from their home ports for six weeks or more (compared with three weeks by conventional distant water trawlers) but, in the main, are smaller than their counterparts from Japan and the Soviet Union. A number are over 61 metres (200 ft) in length but even the largest have a registered length of only about 70 metres (230 ft). Japanese trawlers are up to nearly 91 metres (300 ft) long and the largest Soviet trawler is over 122 metres (400 ft). Both these nations have refrigerated transport vessels which relieve fishing boats of their catches and allow them to remain longer on the grounds. They also use 'mother-ships' which have processing facilities and act as guiding and coordinating centres for fleets of smaller fishing vessels; such a system has not been employed by the British fishing industry, the nearest approach being the provision of a 'guard' ship in Icelandic waters in winter following the sinking of three trawlers in bad weather conditions during the winter 1967–68.

Fishing cannot be regarded as a major employer on a national scale, but the number of persons indirectly dependent upon it for employment is much larger. Probably at least twice as many as those actually fishing are engaged upon such activities as boat building and repairing, net making, fish processing and distribution, providing items of ships chandlery and the general oversight and administration of the industry.

*Employment in fishing*[1]

| | ENGLAND AND WALES | | SCOTLAND | | NORTHERN IRELAND | | UNITED KINGDOM | |
|---|---|---|---|---|---|---|---|---|
| | REGULARLY EMPLOYED | PARTIALLY EMPLOYED | REGULARLY EMPLOYED | PARTIALLY EMPLOYED | REGULARLY EMPLOYED | PARTIALLY EMPLOYED | REGULARLY EMPLOYED | PARTIALLY EMPLOYED |
| 1938 | 26 062 | 2 949 | 12 976 | 4 939 | 342 | 556 | 39 380 | 8 444 |
| 1948 | 25 946 | 3 373 | 12 080 | 5 148 | 800 | 300 | 38 826 | 8 821 |
| 1967 | 10 110 | 3 076 | 8 057 | 1 847 | 508 | 184 | 18 675 | 5 107 |

1. The figures relate to 31 December in each year.

Employment in fishing has been halved since the war. This is due partly to the generally declining state of the industry, but the powerful counter-attraction of regular, fairly well paid work ashore has also been an important factor. The result has been a manpower shortage at many ports which might have been more acute but for the introduction of efficient modern vessels requiring fewer crew members than older craft with equivalent catching power.

There must be relatively few villages around British coasts which do not have some form of commercial fishing, even if it is only providing mackerel or some shellfish for summer visitors. The most important sections of the industry are highly concentrated, however, and over 62 per cent (by value) of fish landed by British vessels at United Kingdom ports in 1967 was

brought ashore at Grimsby (£13.2m), Hull (£12.8m), Aberdeen (£7.9m) and Fleetwood (£4.1m). A further 15 per cent was contributed by vessels landing at Lowestoft, Ullapool, Fraserburgh, North Shields and Leith. A more detailed picture of the distribution is provided in Fig. 110.

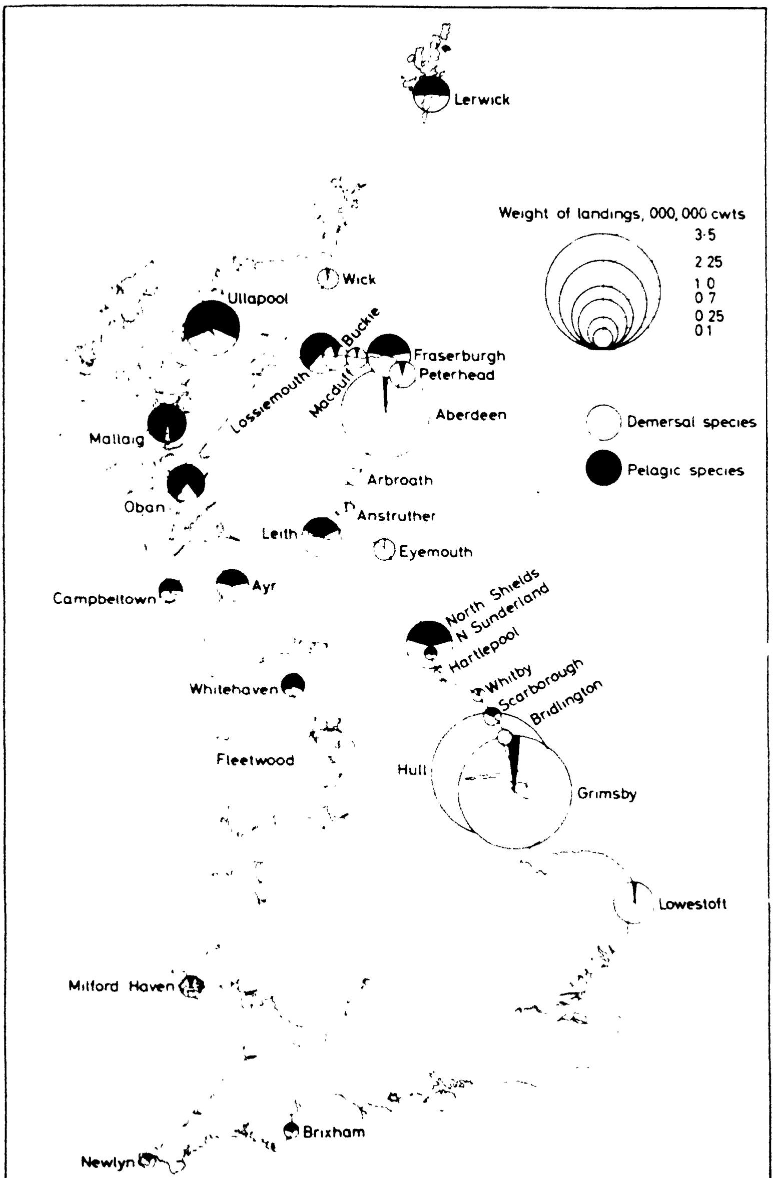



FIG. 110. Distribution of the landings of demersal and pelagic fish on British vessels at principal fishing ports in 1967

*Vessels of 24 metres (80 ft) and over registered length at 31 December 1967*

| LOCATION | 24 M–42.5 M (80–139.9 FT) | OVER 42.59 M (OVER 140 FT) | TOTAL |
|---|---|---|---|
| Aberdeen | 107 | 2 | 109 |
| Fleetwood | 50 | 11 | 61 |
| Grimsby | 79 | 60 | 139 |
| Hull | | 104 | 104 |
| Leith | 20 | | 20 |
| Lowestoft | 108 | 1 | 109 |
| Milford Haven | 20 | | 20 |
| North Shields | 5 | 3 | 8 |
| Others | 9 | 1 | 10 |

Source: Derived from *Sea Fisheries Statistical Tables.*

Most of the distant water fleet is at Hull where there are no vessels less than 42.5 metres (140 ft) in length. Grimsby has more medium and large craft overall but fewer in this category. In terms of landings this has the effect that the Hull catch is rather larger than that made at Grimsby. But, as more of the smaller craft from the latter port fish nearer home, they land fewer distant water cod and more high value fish such as plaice. There are relatively few large trawlers at other centres and these usually exploit grounds no farther afield than the Faroes, Iceland and the Norwegian coast.

Coastal towns or villages normally develop as fishing ports to exploit fish in nearby waters. Early impetus is gained if local grounds are very productive but with major British ports it has been other factors, applied at this stage or later, that have really established their positions. It was in the nineteenth century that the present pattern of port distribution became evident and the railway companies played an important part in the development of the larger centres, not only by providing rail links with major consuming areas and introducing special fish trains, but also by investing in the ports themselves, mainly by providing docking facilities. Probably Grimsby is the best example of a port developed by railway companies. The network reached it in 1848, but there was still little fishing and most vessels on the Humber were concentrated at Hull. During the next five or six years facilities were much improved at Grimsby, while they were still fairly primitive at Hull, where the railhead was over a mile from the landing place. Inducements were offered to owners at Hull and other ports to encourage them to fish from Grimsby. In addition, the railway companies became part owners of a fleet of nine vessels and, by the late 1850s, the port was growing fast.

Aberdeen, Fleetwood, North Shields and Milford Haven were later

developing but they all benefited from the help provided by the railway concerns. It must, nevertheless, be remembered that these organisations were only prepared to invest where there was obvious potential. On the east coast this was provided by the discovery and exploitation of good fishing grounds in the North Sea from about the 1830s. The principal west coast ports of Fleetwood and Milford Haven already had railway connections in the late 1880s and early 1890s, when vessels from Grimsby and Hull were based there while fishing, principally for hake, to the west of Scotland, in the Irish Sea and British Channel, and to the south of Ireland. These ventures were successful, the railway companies helped with the provision of facilities on shore and of suitable transport, and the two centres became established in the front rank of British fishing ports.

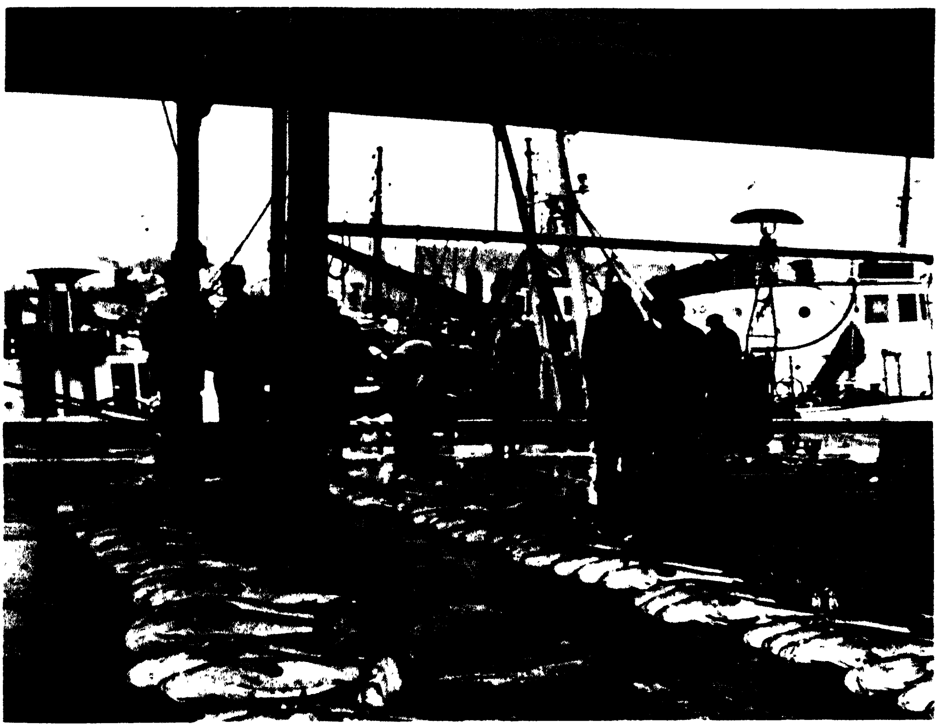


PLATE 8. The fish market at Aberdeen

From about the middle of the nineteenth century other important changes were also taking place. The increasing use of ice for preservation gave added encouragement for craft to remain longer on the grounds or to fish farther afield. Vessels and equipment were being improved, and with the widespread introduction of the steam trawler from the 1880s onwards, many new areas were opened to British fishermen. By the end of the century fishing had taken place around Iceland, Faroes and in the Bay of Biscay; in

1904–05 it had extended to the Murmansk coast and, during the next thirty years, hardly a fishing ground in the North Atlantic between the latitudes of Spitzbergen and Morocco had not been explored. It was during this latter period that Hull became established as a distant water port.

The pattern that had by now emerged was of many small and medium fishing ports whose vessels were exploiting grounds, usually less than 160 kilometres (100 miles) distant, and of a few major ports whose economy was largely dependent upon the produce of relatively distant seas. For these the nearby grounds, so important less than a century before, were of much diminished significance. The inertia that had been derived from the early provision of railway, marketing, processing, repairing, docking, coaling and other ancillary facilities had been sufficient to keep these places in the forefront.

Subsequently, the industry has declined in overall importance and catches by English and Welsh vessels have been reduced, although the smaller Scottish industry has been in a healthier state.

Some temporary reversals to this general trend of contraction have occurred and the most notable was in the late 1940s following the resting of many fishing grounds during the war. Landings at the principal English and Welsh fishing ports are all below the levels attained in the 1930s, but Aberdeen stands out in marked contrast although the present situation there is not encouraging. Greater landings could almost certainly be made from Grimsby and Hull but vessels are frequently laid up because of an absence of a market for their product. The decline at Lowestoft is due to the repeated failure of the East Anglian herring season. Luckily, the port has a sound basis provided by its long standing demersal fishery conducted in the North Sea but Great Yarmouth, its neighbour, was more heavily dependent upon herring and is now virtually finished as a fishing centre.

*Landings of wet fish ('000 tons) at important ports during selected years*

| YEAR | HULL | | GRIMSBY | | LOWESTOFT | | FLEETWOOD | | MILFORD HAVEN | | ABERDEEN | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | METRIC TONS | LONG TONS | METRIC TONS | LONG TONS | METRIC TONS | LONG TONS | METRIC TONS | LONG TONS | METRIC TONS | LONG TONS | METRIC TONS | LONG TONS |
| 1919 | 56.8 | 56 | 134 | 132 | 63 | 62 | 39.5 | 39 | 14 | 14 | 63.9 | 63 |
| 1930 | 213 | 210 | 196 | 193 | 76 | 75 | 61 | 60 | 36.4 | 36 | 84 | 83 |
| 1938 | 291 | 287 | 208 | 205 | 52 | 51 | 69 | 68 | 37.5 | 37 | 88 | 87 |
| 1949 | 251 | 247 | 222 | 219 | 36.4 | 36 | 74 | 73 | 29.4 | 29 | 102 | 101 |
| 1967 | 198 | 195 | 172 | 169 | 23.3 | 23 | 46.6 | 46 | 6.0 | 6 | 107 | 106 |

Sources: *Sea Fisheries Statistical Tables*; *Annual Reports of Fishery Board for Scotland*; *Scottish Sea Fisheries Statistical Tables.*

Hake have made up a large part of the landings at Fleetwood and Milford Haven. The stocks of these fish to the west of the British Isles have been

severely overfished,[1] not only by British vessels but also by those from Spain, France and other Continental countries. Fleetwood has been the less unfortunate of the two ports, for its economy has not been so dependent on a single species of fish and its vessels have been frequent visitors to more distant grounds around the Faroes and Iceland. Additionally, the large fish-consuming Lancashire market is on its doorstep.

The plight of Milford Haven as a fishing port has not been helped by its location. The common difficulty of obtaining crews has been acute here; many of the trawler companies, hit by declining landings, have been in a poor financial state and unable to replace their old and uneconomic vessels, and a visitor to the fish dock sector of the port is confronted with a most depressing sight. The large fish market is only partly used, the once busy railway sidings are silent and there is a general air of decay. The oil industry, for some years a dominant feature of Milford Haven (cf. p. 355), has had little effect on the fishing industry of this area.

From Scottish ports other than Aberdeen, most fishing is carried out inshore or in near waters, by vessels less than 24 metres (80 ft) in length. Even Aberdeen trawlers rarely fish far afield. That catches have not exhibited the marked decline evident in most other fisheries is probably due to the following main reasons: first, many Scottish grounds have not been severely overfished and, like some other British inshore grounds, may well have been helped, recently, by the restriction of foreign fishing activity round our coasts, following the 1964 Fishery Limits Act; secondly, there has been increasing emphasis on demersal fishing to compensate for the declining herring catch; thirdly, a high proportion of vessels here are family owned and manned and there are strong social incentives for keeping them in operation; fourthly, there are fewer alternative employment opportunities available than in England; fifthly, voyages are fairly short and much fish landed in Scotland has not spent long in the hold of a vessel and there is a good demand for it; finally, Scottish fishermen are rather more mobile than many of their English counterparts—they will take their vessels wherever fish are likely to be rather than fish a nearby ground out of production. Most Scottish vessels fishing west coast grounds are from the east coast; once the craft are there the men will fish during the weekdays out of, perhaps, Ullapool or Lochinver and go home to Lossiemouth or some other North Sea centre by road on Friday, returning to their vessels on Sunday night.

At some smaller centres elsewhere in Britain fishing has been successful, but at others it has ceased altogether, and there are many where it continues only because the fishermen have been able to augment their incomes by catering for tourists or taking additional work ashore.

The importance of cod and haddock to the British fishing industry is clearly shown in the table on p. 266. Neither are inhabitants of warmer

1. Overfishing occurs when, over a period, the weight of fish removed from an area is greater than the difference between the weight added to a fishable stock by natural replacement and growth, and that lost to it due to natural causes.

waters, though the cod exists between a wider range of latitudes and shows a preference for colder regions. The species comprises almost the entire catch from the most northerly waters fished (Fig. 110) and, in some years, is significant in landings as far south as the English Channel. Haddock are in small numbers in these extreme areas and the largest catches are made in the northern North Sea, from where Scottish vessels made almost half the total British landings of the fish during 1967.

*Landings of fresh and frozen fish by British vessels at United Kingdom ports in 1967*

| TYPE OF FISH | | QUANTITY ('000 LONG TONS) | VALUE £'000 |
|---|---|---|---|
| *Demersal fish* | | | |
| Cod | | 345 | 25 235 |
| Haddock | | 127 | 10 474 |
| Plaice | | 44 | 5 646 |
| Whiting | | 47 | 2 818 |
| Saithe | | 42 | 1 476 |
| Lemon soles | | 6 | 1 165 |
| Skates and rays | | 11 | 1 048 |
| Hake | | 4 | 976 |
| Halibut | | 2 | 802 |
| Soles | | 2 | 683 |
| Others | | 70 | 3 370 |
| Total | long tons | 700 | 53 693 |
| | metric tons | 711 | |

| TYPE OF FISH | | QUANTITY ('000 LONG TONS) | VALUE £'000 |
|---|---|---|---|
| *Pelagic fish* | | | |
| Herring | | 101 | 2 676 |
| Sprats | | 43 | 374 |
| Mackerel | | 4 | 199 |
| Others | | 1 | 29 |
| Total | long tons | 149 | 3 278 |
| | metric tons | 151 | |
| *Shellfish* | | | |
| Norway lobsters | | 9 | 1 686 |
| Lobsters | | 1 | 903 |
| Crabs | | 4 | 409 |
| Shrimps | | 2 | 228 |
| Cockles | | 15 | 218 |
| Others | | 10 | 557 |
| Total | long tons | 41 | 4 001 |
| | metric tons | 41.6 | |
| Total all fish | long tons | 890 | 60 972 |
| | metric tons | 904 | |

1 long ton = 2240 lb = 1.016 metric ton
Source: Derived from *Sea Fisheries Statistical Tables.*

Four flatfish appear in the above table. Halibut, the largest of them, frequently attain a weight of over 45 kilograms (100 lb); they are caught in deeper waters, particularly around the Faroes, where they form the most important items in the catch of Scottish line fishermen. Good landings are also made by trawlers around Iceland and on the Grand Banks but these fish are generally taken from shallower waters and are somewhat smaller than the line caught fish.

None of the other three flatfish lives in waters as deep as those frequented by the halibut. They are all taken principally from the North Sea. The sole, the least important of the trio, is also least tolerant of low temperatures. It is taken mainly from the shallow waters of the southern North Sea, the English and Bristol Channels and the Irish Sea. Few appear in Scottish

catches. Plaice and lemon soles are wide-ranging and important in areas as far apart as the English Channel and Iceland. Further north lemon soles are only taken in small quantities while plaice are significant in the Barents Sea. Generally, lemon soles inhabit deeper waters than those in which plaice normally live; this is shown clearly in the North Sea where the former are taken in largest quantities from the deepest northern parts while plaice, like soles, are caught mainly in the south.

Although caught in quite large quantities, the saithe, or coalfish, a member of the cod family often retailed under the name 'coley', has a low value and cannot be regarded as a popular food fish. It is taken from most of the areas frequented by cod but in only small quantities from the northernmost of these. It is important in catches made around Iceland and Faroes, off the Norwegian coast and the west of Scotland, and in the North Sea.

The whiting is taken in largest numbers by Scottish vessels, principally from the North Sea but also off the west coast. Catches by other British craft in the North Sea, the English and Bristol Channels and the Irish Sea are quite considerable but it is found in only small quantities to the north of the British Isles. The level of exploitation of the whiting stock, particularly by Scottish fishermen, is frequently a reflection of the abundance of the more valuable haddock for, when the latter are scarce, greater emphasis is placed on fishing for whiting.

The remaining fish mentioned in the table are hake and skates and rays.

The general category 'skates and rays' contains a number of different species and some occur in nearly all the regions exploited by British vessels. They are sometimes found in shallow waters, most are taken off the western coasts of Britain but good catches are made from the North Sea, particularly in the north.

Hake are normally inhabitants of deeper waters at the edge of the continental shelf or on the continental slope but some migrate around the north of Scotland into the North Sea during the summer. The greatest landings are made from the west of Scotland, in the Irish Sea and in the northern North Sea. Formerly, large catches were made to the south and west of Ireland and it is important off the coasts of Portugal and Morocco. The severe overexploitation of this fish to the south and west of the British Isles and the decline of Milford Haven have already been mentioned. Cardiff and Swansea, now insignificant as fishing ports, had sizeable fishing fleets, largely dependent upon hake, in the late 1940s and early 1950s. The total British landings of the fish were just over 4064 metric tons (4000 long tons) in 1967, compared with over 25 400 metric tons (25 000 long tons) in 1949 when landings from the south and west of Ireland alone amounted to over 11 180 metric tons (11 000 long tons). In 1967 about 40 metric tons of hake were taken by British vessels from the same area; admittedly, many fewer trawlers are now operating but it is the reduction in catches that has played a major part in making the operations uneconomic. It is interesting to note that, over the postwar period, the decline in the value of hake landings has

been almost as great as that accompanying the much publicised fall in the herring catch. In 1948 the hake was fifth in total value of British wet fish landings and fetched £3.5m at first sale; the herring was fourth at £5.4m. The respective figures for 1967 were £1m (ninth) and £2.7m (fifth).

Many of the other demersal species have also been under pressure. Indications may be given by declining catches per 100 hours fishing and a preponderance of small fish in the catch. Alterations in total landings from a particular area can be misleading, for these may only indicate changes in fishing effort. Total national catches are even more suspect in this respect. For example, landings of cod by British vessels in England and Wales were rather lower in 1967 than in 1949 but considerable changes of emphasis are hidden by these figures; during the earlier year nearly two-thirds of the total came from northeast Arctic grounds of the Barents Sea and around Bear Island and Spitzbergen but, because of declining productivity here, the main fishing effort was diverted elsewhere, and by 1967 the largest catches were being made in Icelandic waters and there had been a significant increase in catches from the northwest Atlantic, particularly following the development of freezer trawlers.

*Cod landings from principal areas by British vessels at English and Welsh ports in 1949, 1967 and 1969*

| AREA | | LANDINGS ('000 LONG TONS) 1949 | 1967 | 1969 |
|---|---|---|---|---|
| Barents Sea | | 139 | 39 | 107 |
| Norwegian Coast | | 19 | 23 | 56 |
| Bear Island and Spitzbergen | | 64 | 9 | 26 |
| North Sea | | 26 | 40 | 36 |
| Iceland | | 62 | 104 | 78 |
| Faroes | | 10 | 6 | 6 |
| West Greenland | | 12 | 16 | * |
| Grand Banks | | * | 35 | 2 |
| Labrador | | * | 7 | 2 |
| Others | | 8 | 14 | 10 |
| Total | long tons | 340 | 293 | 323 |
| | metric tons | 345 | 298 | 328 |

* Less than 1000 tons.
1 long ton = 2240 lb = 1.016 metric ton

Source: *Sea Fisheries Statistical Tables.*

The British were not alone in diverting vessels; much of the Soviet fleet operated there following the over exploitation, for which it was largely responsible, of the northeastern Arctic grounds in the period 1960–63.

German, Portuguese and other fleets were also well in evidence. This international reduction in fishing effort in northern European waters allowed stocks to recover, and the figures for 1969 tell the story of the resulting action taken by fishing companies.

If we now turn to an examination of the pelagic species, the dominance of the herring is clear. This fish is far more important to the Scottish fisheries than to the English and the greatest landings are now made off the Scottish west coast, although the east coast used to be more important. It is taken throughout the year from these western areas and, although there are seasonal differences, they are not as marked as in the North Sea. At Ayr the minimum is during the autumn, at Campbeltown it occurs in the winter and, farther north, it is during the summer.

*Distribution of the herring catch (in '000 long tons) by ports in 1967*

| | | |
|---|---|---|
| Ullapool | | 26.2 |
| Mallaig | | 16.0 |
| Oban | | 13.6 |
| Fraserburgh | | 8.3 |
| Lerwick | | 7.8 |
| Ayr | | 5.5 |
| Whitehaven | | 3.8 |
| North Shields | | 3.5 |
| Campbeltown | | 3.2 |
| Stornoway | | 2.2 |
| Lossiemouth | | 1.5 |
| Aberdeen | | 1.3 |
| Scarborough | | 1.2 |
| North Sunderland | | 1.0 |
| Lowestoft | | 0.6 |
| Grimsby | | 0.6 |
| Peterhead | | 0.5 |
| Yarmouth | | 0.5 |
| Milford Haven | | 0.5 |
| Others | | 3.2 |
| Total | long tons | 101 |
| | metric tons | 102.6 |

Ring netting is the most important method used in the sheltered waters of the Clyde and the Minches. It is rarely employed in other Scottish waters where weather conditions are less reliable and more fish are taken in drift or trawl nets. Purse seining, although similar in many ways, has been used

more widely and has been responsible for good landings at some Scottish east coast ports, among which Fraserburgh has been notable. Drifting is important on the west coast only from Ullapool, where a number of vessels fish in the more open waters of the North Minch. Trawling accounts for many herrings in the Minches but it is little used in the Clyde.

West coast fisheries other than the Scottish are of small importance. There are two that may be mentioned, both being operated during the summer. One is around the Isle of Man and off northeast Ireland, mainly by drifters and ring-netters; the other, worked mainly by trawlers sometimes landing at Milford Haven, is off southern Ireland between the Smalls lighthouse and the Old Head of Kinsale.

It is well known that in the North Sea large-scale fishing begins each year in the north and moves southwards during the summer and autumn. It must be stressed that although there is clear evidence of some southward movement of mature and maturing fish, it is not the movement of one stock but of several, each appearing progressively farther southwards. After spawning, the fish return northwards to spend the winter in various deeper parts of the North Sea.

Mainly to the north of 55°N the catching of immature herrings and recovering spents (those that have recently spawned) begins in May. By June, feeding is at a much higher rate and good quality maturing and immature fish are taken. Up to this time fish are landed in the Shetlands, along the Scottish east coast, principally at Fraserburgh, but also at Aberdeen, Lossiemouth, Peterhead and other centres and on the English northeast coast, where North Shields is the main centre.

There is a steady improvement during the next two months and shoals spread farther southwards. In August spawning takes place in the northern North Sea and these fish are taken off northeast Scotland; mixed shoals of full and spawning fish occur off the English coast as far south as Scarborough and provide the basis for the main Yorkshire fishery.

These fisheries are mainly prosecuted with drift nets and, by the end of August, there is little activity north of the Yorkshire coast, where fishing usually finishes about a month later.

The annual east coast drift fishery culminates in the southern North Sea and eastern English Channel when, between about the beginning of October and Christmas, shoals of mature fish head southwards to spawn off the northern French and Belgian coasts. This fishery is of small importance to the economy, contributing, in 1967 1 120 metric tons (1 100 long tons) to the British herring landings of 102 600 metric tons (101 000 long tons), but it is notable because of its history.

In the past, large numbers of Scottish and English drifters were based at Yarmouth and Lowestoft during the season but nowadays few Scottish vessels find it worth while to make the trip, particularly as the fisheries in The Minches at the same time are much more profitable. East Anglian landings reached their peak in 1913, a year when English and Welsh herring

landings totalled 372 000 metric tons (366 000 long tons) (compared with 12 000 long tons in 1967). Subsequently there has been an almost continuous decline interrupted only by temporary revivals after both world wars.

The British trawl fisheries for herring in the North Sea are of little consequence compared with those carried out by continental fishermen. The Fladen grounds in the northern North Sea between the Scottish and Norwegian coasts were found in 1911, by an Aberdeen skipper, to be productive for herring trawling; the area fished was extended southwards, and vessels from Germany, Denmark, France, Belgium and Sweden were soon operating over a wide area between the Humber and the Orkneys and making very large catches. Since the second war there has been intensive trawling of the spawning stocks off the north French coast, and in 1948 a fishery for immature herrings on the Bløden ground, between the Dogger Bank and the Danish coast, commenced and enormous hauls have been made by continental vessels. Most of these trawled fish are consigned to factories for conversion to meal and oil.

Several factors have almost certainly been responsible for the general decline in herring landings. There was a considerable reduction in demand both at home and on the export market after the First World War. In 1913 the greatest part of the herring catch was exported, in pickled form, mainly to Russia, Germany, France and Belgium. After the war, the trade with Russia and Germany, the principal customers, was seriously curtailed, partly because of their political problems but also because they were developing their own fishing fleets. Subsequently exports have continued to decline and increasing reliance has been placed on the home market, but here, too, consumption has fallen.

It is also true that stocks of herring in the southern North Sea have been seriously depleted. Admittedly, catches might have been expected to fall, if only because of the smaller number of vessels operating, but there is undoubtedly a shortage of fish due, almost certainly, to the extensive trawling by continental boats on the spawning grounds in the southern North Sea and the eastern English Channel and the taking of immature fish on the Bløden grounds.

The British have never developed an interest in large scale exploitation of herring for fish meal although surplus and condemned fish go to this outlet. Nevertheless about 40 per cent of the herring catch goes for processing for human consumption; most are kippered, while good quantities are canned, marinated and pickle cured for export and some are made into bloaters or red herrings. Most of this processing is concentrated at Fraserburgh, Aberdeen and Peterhead and fish are even taken in fair quantities from England to be dealt with there.

Sprats are taken mainly for processing but most of these are consigned to fish meal plants and many go for petfood manufacture. Some are canned at Fraserburgh and brought to the factory from as far away as the south of England. Others are smoked and a few arrive on the fresh market.

The fishery for sprats was transformed during the 1950s following the introduction of the pair trawl, but the main expansion followed the commencement, in the early 1960s, of intensive operations along the Scottish east coast, particularly in the Moray Firth but also in the Firth of Forth and the Buchan area; smaller catches are made around the Shetlands and in the Clyde. The English landings are less and sometimes even minute by comparison, but in most years could be much larger if an outlet were available for them; the prices are so low that it is often not even economical to transport the fish to meal and oil plants. The main catches are, again, made along the east coast; vessels from Grimsby and several other centres fish in the area of the Wash and good landings are made at North Shields.

It was in the Thames Estuary, from Whitstable, that commercial pelagic pair trawling was introduced to this country in 1950, but little is carried on at the port now. Fish were landed in considerable quantities there and at Southend in the early and middle 1950s and again in the early 1960s. At other times fish have not been in the area. The remaining significant fisheries are on the south coast, principally from Poole and the Torbay ports.

The other pelagic fish are mackerel and pilchards; both are landed principally in Cornwall although sizeable catches of the former are made in Scottish waters. Taking mackerel on lines from small boats during the summer and autumn is now the main fishery activity at many ports in Cornwall and, to some extent, has made up for the drastic postwar decline in landings of pilchards and demersal fish in the area. Before, and for a few years after the Second World War, there was an important drift fishery for mackerel by boats from Scotland and the east coast of England, which were based at Newlyn each year after the main herring season was finished farther east. They operated south of Ireland and in the western English and Bristol Channels. Catches were reduced and drifters scrapped as the herring fishery declined, and visits from these vessels finally ceased in the late 1960s.

During this century pilchards have been caught mainly in drift nets but formerly other methods were employed. The fish have been important, but since 1953, when the largest postwar landings of nearly 6100 metric tons (6000 long tons) were made, the picture has been of decline, and less than 1000 long tons were brought ashore in 1967.

Certainly, there have been fewer fish on the traditional inshore grounds, but there has also been an absence of good market demand. Before the war most fish were cured in brine and exported to Italy. The trade collapsed but the curing was replaced by canning, mainly for the home market; unfortunately, this, too, declined considerably as the canners were unable to compete with relatively cheap imports of canned pilchards from South Africa and South-West Africa.

The most marked feature of the shellfishing part of the industry postwar has been the boom in landings of Norway lobsters (scampi) since the late 1950s. Earlier, the market for these had been extremely limited and the creatures were often discarded as valueless but, with the rising standard of

living and the acquisition by many people, through foreign holidays, of a taste for similar shellfish, it was not difficult to create a demand.

They are trawled at many places around the Scottish coast, mainly on the western side but also in the east and off the English northeast coast and from Northern Ireland. They are taken by road to processing plants at places such as Aberdeen, Lossiemouth and Buckie where they are deep frozen, packed and dispatched to various parts of the British Isles, perhaps for export.

The other principal crustaceans are lobsters, crabs, shrimps and crawfish. Lobsters prefer rocky areas and this valuable shellfish is taken at many places around the Scottish coasts but nearly one-third of the total catch (by value) in 1967 was made in the Shetlands, and at Wick, Stornoway and Mallaig. The smaller landings in England and Wales are mostly made on the coasts of northeast England, Cornwall and west Wales but they are also significant in other English Channel waters west of Eastbourne. Unfortunately, catches have been declining in the last few years and this may be a sign of overfishing.

Crab landings have been more stable in England although they, too, have declined in Scotland. These crustaceans are more important in England that in Scotland and few are taken in Wales. They may be found in somewhat deeper waters than is normal for lobsters but are also in many of the same areas. The biggest landings are made on the Scottish east coast, in the Shetlands, on the English northeast coast and in the English Channel off Devon and Cornwall, particularly at Dartmouth and Plymouth. In Norfolk, Sheringham and Cromer are famous for crabs.

The remaining larger crustacean, the crawfish, is a warmer water creature and landed in only small quantities outside western Cornish waters. It is a more familiar fish on the continent where high prices are paid and, consequently, most are exported. Shrimps inhabit shallow sandy areas and the main catches are made in Morecambe Bay, the Ribble and Dee Estuaries and the Wash.

About 4 million oysters are now produced annually. This is many fewer than before the war or, indeed, shortly after the conflict. In 1938 there were over 16 million marketed and, for 1949, the number was 8 million. The famous Whitstable beds are now of little importance and are used for fattening small numbers of oysters from other areas. In Essex the beds in the rivers Blackwater, Colne and Crouch still have a good production but it is in Cornwall, on the Helford river and the various inlets leading into the Fal, that the principal beds exist. Even these are dependent, for young oysters, on stock imported from France and other countries and good local spatfalls (layings) are few.

The decline of the east coast beds has been the result of mainly physical disasters. Just as production was being resumed after the war, many oysters were killed in the hard winter of 1946–47. Subsequent misfortunes were the floods of 1953 and the winter of 1962–63. The Cornish stocks

escaped the worst of these adversities and the grounds in the west country have also been more free of pests.

Escallops are taken between depths of about 18 and 55 metres (10 and 30 fathoms) from many areas around the British Isles, usually in small quantities. There are grounds near the Isle of Man, in the English Channel off South Devon and southeast Cornwall and off Newhaven in Sussex. In recent years, however, the largest catches have been made in western Scottish waters and brought ashore principally at Campbeltown and also at Mallaig, Oban and Ullapool. Good landings have also been made at Lerwick.

Two other shellfish to be mentioned are cockles and mussels. The former occur in many places but the most significant commercial beds are nearly all at the mouths of large rivers particularly in the outer Thames estuary, the Wash and in the Burry Inlet in South Wales. Mussels are also widespread in occurrence and may be found attached to piers, rocks and jetties but the largest commercial quantities are in estuaries with gravelly or stony beds and most are taken from the Wash, the Conway estuary and the Menai Straits.

Fish marketing has undergone many changes in the postwar period but some aspects are extremely antiquated; it is still not unusual for fish to pass through three markets before reaching a retailer. The effect of the attendant delay and handling inflicted on a perishable product can easily be imagined.

Demersal fish are usually first sold at a port auction market by an agent acting on commission for the vessel owner. The fish may be bought by a firm of freezers or by a major retailing organisation which would possibly send its purchase to a central depot before final distribution. Some might be bought by local retailers or by a wholesaler who would either distribute his fish by rail or road to retail outlets or send it to an inland market where it might be sold, but probably not by auction, to a retailer. The larger markets, as at Billingsgate or Manchester, act not only as gathering points for fishmongers of the region but also distribution points for wider areas. Consequently fish may be bought here by yet another wholesaler who might send some to be sold at a smaller inland market. It is quite likely that at some point along the path, and probably at the port market by the wholesaler, the fish may be filleted.

Many port markets have gone out of existence and the throughput of others has been reduced, partly because of smaller catches but also because more boat owners are dealing directly, or through their agents, with freezing companies and, additionally, because more fish are being frozen at sea and need specialised handling. In 1969 over 20 per cent of the wet fish catch was quick-frozen either at sea or on landing and the amount is increasing every year.

Some fishermen, particularly at small ports without a market, have been sending fish directly to inland markets instead of to the nearest port market.

A number of cooperatives have also been formed, again at smaller centres, and the members have taken over the marketing function at the port, obviously to their benefit.

Inland markets have also been in decline. They are being bypassed as direct trading between retailers and the ports has become more popular and have suffered because of the increase in fish being frozen and then distributed by the processers. This in turn has affected the fishmongers who no longer have a virtual monopoly of fish retail selling now that many types of stores offer frozen foods. There has been a reduction in the number of private fishmongers and this has further reduced the potential market customers. Finally, a greater part of the conventional retail wet fish trade is being undertaken by multiple fish retailers who buy at the ports and do their own distribution.

Pelagic fish may be sold in broadly the same way as demersal fish, but a higher proportion is sent directly to processers, and a particular canner may have a number of vessels fishing for him.

Shellfish are not auctioned and may be disposed of to a wholesaler or by direct sale to a private buyer. Lobsters, crabs, crawfish and Norway lobsters are mainly sold to a port wholesaler, who may process them in some way, prior to dispatch. Lobsters and crawfish, however, are normally sent live.

The postwar period has seen a change of emphasis in fish transport from rail to road. This is partly connected with the decline of the traditional marketing system for, with more direct dealings between the ports and retailers or inland wholesalers outside the largest markets, smaller loads have to be carried to a greater number of places and road transport is obviously more suitable; in addition, the pricing policy of British Rail has not encouraged the use of their transport for small consignments. Many processers and wholesalers now rely largely upon road transport and own fleets of vehicles, often of a specialist type such as those used for carrying frozen foods. Road improvements have encouraged the trend which has been further accelerated by the effects of recurrent labour difficulties and the closure of some railway routes.

More expensive fish, mainly shellfish, are sometimes transported by air, both within Great Britain and to the continent. Frequent consignments of shellfish are exported from Southend, Land's End, Exeter and other airports.

Considerable financial assistance is provided for the industry by the Government, and administered by the White Fish Authority and the Herring Industry Board. Modernisation is encouraged by the payment of substantial grants and loans for the purchase and improvement of vessels and, also, by the provision of loans for processing and ice plants on shore. Aid is given to encourage the formation of cooperatives, and finally there are operating subsidies which, for vessels less than 24 metres (80 ft) in length, are paid at a rate per day at sea or per stone of fish landed, and for larger craft are related to a measure of their operating efficiency.

Even with this assistance, many problems remain and the non-freezer part of the distant water fleet is extremely vulnerable. Its catches are sometimes unsaleable because of poor quality on landing, and it is important that ways are devised of keeping the fish fresher; experiments in transferring it to freezer trawlers on the fishing grounds have been carried out, and if these are extended, they may provide the answer until all the distant water catch is frozen on board the catching vessels.

Inshore fishing is concentrated at rather fewer ports than some years ago and, recently, this section, particularly in Scotland, has been in a much healthier state. It accounts for more than a quarter of the total supplies. Quality of fish is good and catches have been improving, probably at least partly due to the effect of the Fishery Limits Act of 1964.

Nevertheless, catch rates in this sector are low compared with those of vessels fishing more remote waters where the main immediate future must lie. The effects of intensive exploitation on many distant grounds by vessels of several nations have been mentioned and we have witnessed a change of emphasis from the northeast Arctic to the northwest Atlantic. Present international conservation measures are obviously inadequate in such situations and, if fish are to be protected, other action must be taken, but the difficulties of obtaining international cooperation for major revisions are enormous. In the meantime, additional fishing areas need to be explored; experimental voyages have been made in the past few years to the south Atlantic to catch silver hake. Perhaps these and other stranger fish will become regular items on our menu.

Aids to modern fishing are numerous and expensive and the industry now has many extremely complex craft, but in essence its philosophy is the primitive one of badly controlled hunting. One cannot help but wonder if it is not this that really needs revision and if greater money and effort should be channelled into fish cultivation.

# 14
# Fuel and power

In the preceding consideration of agriculture, forestry and fisheries particular emphasis has been laid on the changes that have been wrought, during the period since the First World War in particular, by technological advances and by alterations in the general economic situation of the country. Turning now to the major industries and their bases of resources, fuel and power, we shall find that the changes are even more revolutionary—that we are living in the middle of what may well be described by future historians as the 'Second Industrial Revolution' of the mid-twentieth century. This 'revolution' has been brought about—just as that of 1760–1830 was—by new 'inventions', entailing the use of new materials and new sources of energy, derived perhaps from quite different localities than hitherto and contributing to fundamental changes in the geographical balance and the economic fortunes of the various parts of Britain.

Amongst the most important of these changes are: (*a*) the declining use of coal, with the vast increase in the use of electricity (which, however, is still mostly generated through the agency of coal), an equally massive increase in the use of oil, with all that this entails in the necessity for imports, in the growth of refining industries and petrochemical industries at both old and new ports, and in the almost complete cessation in the use of coal as a fuel in ships (which in turn has resulted in the virtual death of the British coal export trade), and the advent of a completely new source of energy in the shape of North Sea gas; (*b*) the phenomenal growth of the automobile and aircraft industries with their insatiable demand for a thousand-and-one components involving many subsidiary industries; (*c*) the development of manmade fibres, entailing the growth of new chemical industries to make the fibres and with important economic consequences for the older textile trades; (*d*) the growth of a vast array of electrical and electronic industries—domestic and industrial appliances, radio, television and now computers—that have quite different localising factors from those characteristic of nineteenth-century industry.

It is the purpose of the first of these industrial chapters to examine the fuel and energy supplies upon which the British economy is now based.

## COAL

Coal has always been Britain's main mineral product, and though (see Chapter 15) gravel and limestone together now represent a greater tonnage, coal remains of overwhelming importance both in terms of the value of the output and in terms of the employment that it offers. In 1967 coal output of 173.7 million metric tons (171 million long tons) compared with gravel 106.7 million metric tons (105 million long tons) and limestone 76.2 million metric tons (75 million long tons); but in the same year the coal industry employed 412 000 people and all other mining and quarrying industries together less than 50 000.

It is obviously true to say that Britain's industrial development has been based on coal. But as a source of energy its dominance has been greatly reduced by the importation of ever-increasing quantities of crude oil (more than 76.2 million metric tons (75 million long tons) in 1968 as compared with 9.1 million metric tons (9 million long tons) in 1950) and more recently by the construction of several nuclear-based power stations mainly in coastal locations. In 1968 North Sea gas was also beginning to make significant inroads into the energy market. The difficulties which beset the coal mining industry immediately after the Second World War have been too loosely interpreted as being related essentially to the exhaustion of workable reserves. This was certainly far from the truth, though it might have been argued that substantial quantities of the more readily accessible coals had already been extracted, particularly in the older coalfields of the country.

Coal has been worked in Britain since very early times. The discovery of coal cinders in the ruins of Roman towns makes it probable that the Romans used coal during their occupation of the country. The *Anglo-Saxon Chronicle* records its use in monasteries in the ninth century. By the thirteenth or fourteenth century there was a well established trade in seaborne coal from Newcastle and Tyneside to London. The early shallow workings were naturally along the outcrops of individual seams, but coal at or near the surface is apt to be badly weathered and unobtainable in lumps suitable for transport and burning. Small adits or drifts following the seams into the hillsides provided better-quality coal, but the opening of these often gave rise to problems of drainage and roof support. Bell pits and small mines with haulage shafts allowed slightly deeper-lying seams to be worked. Generally, however, no systematic form of shallow mining was developed. No records were kept, with the result that at their uppermost levels many seams are still honeycombed with unchartered irregular excavations. In recent years some of this coal lying at no great depth has been extracted by opencast means and, more locally, by small drift mines operated both by the National Coal Board and under licence as private concerns. Where the incidence of old workings is high and a flood risk is known to occur no exploitation of any remaining reserves is now likely to take place.

In general terms the story of development is the same for all the British

coalfields. There was first, as described above, the spasmodic local working in open pits or shallow mines; then came larger mines with deep shafts and associated colliery villages or mining towns, with all the attendant network of services and communication—the improvement of roads or construction of tramways, and later the extensive building of canals, rendered obsolete by the advent of railways. The industrial regions took on the high degree of specialisation characteristic of Britain—Lancashire with cottons, the Leeds–Bradford area of Yorkshire with woollens, the Sheffield area with steel and cutlery, the Black Country with iron smelting and so on.

Coal mining, however, is a robber industry and although a state of complete exploitation is not physically possible it should be apparent that in due course the more accessible and better-quality reserves will be largely exhausted. In Britain this has already happened in the old Black Country of southern Staffordshire and neighbouring parts of Worcestershire, and in the Forest of Dean. During the past twenty years many of the older coalfields of Britain have shown a progressive shift of mining activity to the deeper or 'concealed' sections so that capital outlay has been greater and individual units now have an extended geographical range of operations and generally higher outputs.

## Nationalisation and recent progress in the industry

The British coal mining industry was nationalised on 1 January 1947 when the National Coal Board and its component Divisional Board were established. The Board was charged with the task of reorganising and re-equipping the industry. Apart from the slight industrial recession in 1951–52, the period from 1947 to the end of 1956 was featured by an expanding economy with an average annual increase in the inland demand for coal of 3.2 million tons. For ten years the industry was therefore, from a production angle, geared to an expansionist programme. The problem of overproduction, which was brought to light in the latter half of 1957, was totally unexpected. To avoid wholesale closures of collieries, some with substantial reserves, and the dismissal of thousands of miners, stocks of coal were allowed to build up and by the end of 1959 these reached a peak level of nearly 36.6 million metric tons (36 million long tons). The main reasons for this decline in demand were the industrial recession in the United Kingdom and the increasing usage of alternative, more convenient and, sometimes, cheaper forms of fuel, particularly oil.

These entirely unforeseen changes within the British coal mining industry, involving as they did the serious problems of mounting stocks and diminishing demand, forced the National Coal Board to draw up its third major plan (1959) within the space of ten years. Forecasts made in this plan for the production and manpower levels in 1965 have subsequently proved

to be far too high; nevertheless, much of the future policy then outlined has been implemented in the mining programmes evident up until 1968.

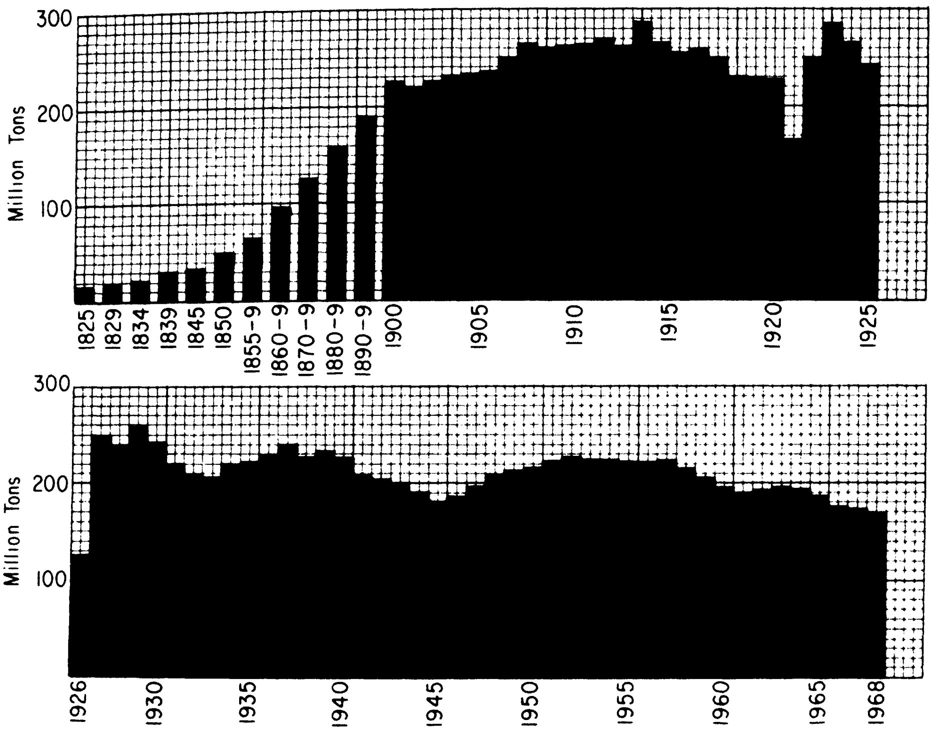



FIG. 111. Graph showing British coal output, 1825–1968

A major effort has been directed at the improvement of all-round efficiency within the industry. In the latter half of 1968 output per manshift (overall) at the Board's collieries had reached the encouraging level of 2.2 metric tons (43 cwt) and it was confidently anticipated that this would exceed 2.5 metric tons (50 cwt) by 1970–71. No other British industry could match this productivity spurt and now it perhaps can rightly be claimed that the British coal mining industry leads the world in technical deep-mining developments. To achieve this end the closure of uneconomic or low-yielding collieries, more especially in the older coalfields of Scotland, Northumberland and Durham, Lancashire and South Wales has been drastic. Between March 1965 and March 1968 no less than 164 collieries, mainly in these categories, were closed or merged. In 1968 more than 90 per cent of the deep-mined output was produced by mechanised methods. Resources are being directed to those collieries with the greatest potential as the less economic collieries are closed. The continuing collieries will be producing from fewer, more productive, faces and at lower costs.

The enforced contraction which the industry has suffered resulted in a

certain lack of faith in its future stability. As a consequence the drain of manpower through normal wastage, a reduction in recruiting and transfer into other occupations reached near-flood proportions at times. Thus the average overall colliery manpower has markedly diminished from 693 000 in 1958 to 392 000 for the year ended 30 March 1968. The Board consider it essential to maintain an adequate labour force in the low-cost central coalfields, but this is particularly difficult at a time when because of uncertainty about the long-term future, wastage from the industry will probably increase. It is a corollary of the progressively increasing productivity rates that the rundown of production has not been of such a drastic order. The output of deep-mined coal (National Coal Board and licensed mines) for the year ended 30 March 1968 was 166.6 million metric tons (164 million long tons) as compared with 204.7 million metric tons (201.5 million long tons) in 1958.

PLATE 9. The 'new look' of a modern colliery: Parkside in south Lancashire. The concrete towers house the shaft-heads

## The disposition of the coalfields

Unlike her neighbours on the continent of Europe, Britain has practically no production nor resources of lignite or brown coal. The small field containing such coals of Tertiary age at Bovey Tracey in Devonshire is unimportant. Britain's coals are nearly all of Carboniferous age; those of England and Wales occurring in the Coal Measures (Upper Carboniferous), those of

Scotland in both the Lower and Upper Carboniferous. There is an isolated mine at Brora on the coast of Sutherland in northern Scotland, which works coal of Jurassic age. Britain is perhaps unfortunate in that a former wide spread of Coal Measure rocks has been broken up into a number of separate small areas by subsequent earth movements and denudation; and an attempt to reconstruct the geography of the period may assist in the understanding of the disposition of existing fields.

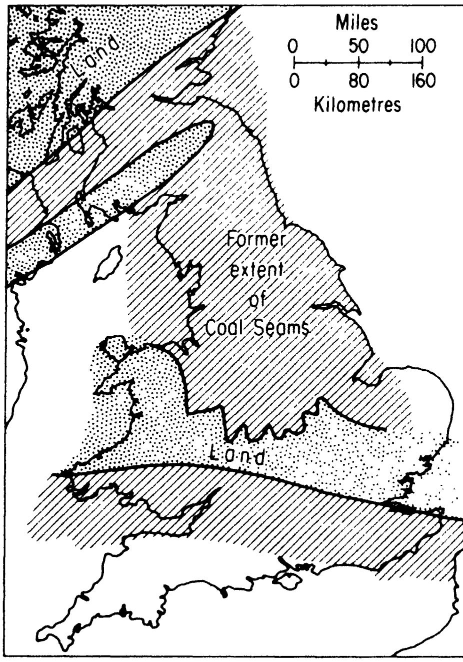



FIG. 112. The geography of the Coal Measure period

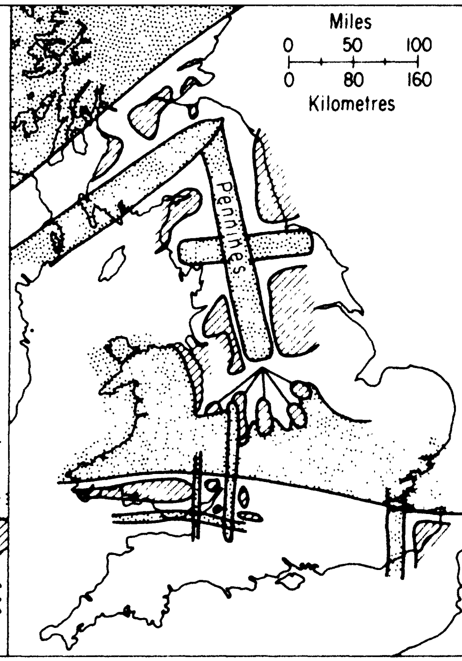



FIG. 113. The effect of subsequent earth movements in separating the British Coal Measures into a number of basins

In Chapter 2 we have already outlined the conditions under which the Coal Measures of Britain were deposited.

In early Carboniferous time the present Highlands of Scotland formed part of a great continental mass. Along its southern fringe were deltaic flats, and on them flourished the extensive swamp forests from which coals of Lower Carboniferous age derive. These older coal seams die out southward except for a few in Northumberland. It was not until Upper Carboniferous time that conditions suitable for the growth of coal forests spread over the larger part of England and Wales. At that time, it is believed, a great deltaic flat stretched from the margin of the Scottish land mass to St George's Land, a low land ridge crossing the Midlands of England. Along the southern fringe of St George's Land conditions were also suitable for the growth of Coal Measure forests, but farther south (in Devon and Cornwall) rocks

of the same age are barren. St George's Land remained relatively stable during Coal Measure time, whereas the areas to the north and south underwent successive depressions. It would seem that there were thus originally two enormous coalfields of Upper Carboniferous or Coal Measure age, one reaching from the Highlands of Scotland to the Midlands of England, the other lying south of St George's Land and extending from South Wales across southern England into Kent and on into northern France and Belgium. In the northern area, coal seams traced southward towards the old land bridge are found to get gradually closer together and, in some places, eventually to merge. This is the case with the famous Thick Coal—as much as 11 metres (36 ft) thick—of the South Staffordshire or Black Country coalfield, and this explains why the coals in some of the Midland fields have been virtually worked out.

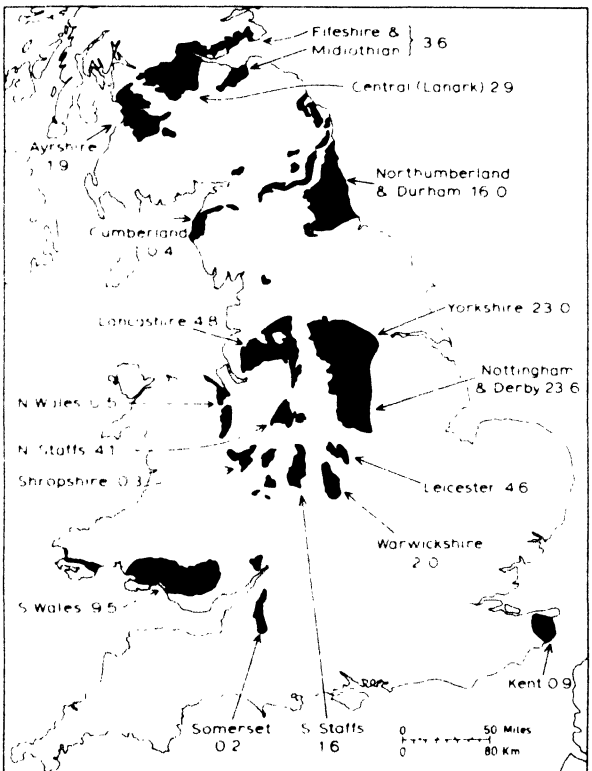



FIG. 114. The coalfields of Great Britain and their production in 1968 expressed as a percentage of the total national output

The Armorican or Hercynian earth movements at the end of the Carboniferous period flexed the British Coal Measures into a series of east–west and north–south folds. Where two downfolds cross, an oval basin may be formed,

as in the little Forest of Dean coalfield. Folding and subsequent denudation of the anticlines resulted in the separation of the British coal deposits into a series of basins. Each basin is geologically a distinct unit and may be said to constitute a coalfield. Where the basin is completely surrounded by older rocks the exact extent of the field is known, and total reserves can be closely calculated. The South Wales and Forest of Dean fields are good examples of such basins; the Scottish fields afford other examples. In other places the Coal Measures may plunge down or be faulted down to such depths that the existence of coal can only be assumed; in any case it is beyond workable depth. Thus between the North Wales and Lancashire fields coal probably underlies the whole Cheshire plain, but at depths certainly exceeding 1200 metres (4000 ft). In still other places the Coal Measures plunge beneath younger rocks or the sea, and the precise limits of the field remain unknown. This is the case with the great Yorkshire and Durham fields.

Unfortunately, different parts of a single geological coal field may be given separate names, and in recent nomenclature has been further confused by the adoption of regions with new names.[1]

The extent of the fields as known at present is shown on the official map of Coal and Iron on the scale of 1 : 625 000 prepared by the Maps Research Office of the Ministry of Housing and Local Government and published by the Ordnance Survey.

## British coal reserves

No calculations have been made recently of Britain's total coal reserves. A summary made in 1947 from the published Regional Survey Reports of the Ministry of Fuel and Power suggested that the known workable reserves in seams 46 centimetres (18 inches) and more in thickness, to a depth of 1200 metres (4000 ft) and exclusive of reserves considered not economical to work at that time amounted to something like 40 000 million long tons. Despite the extra data now available the National Coal Board has not embarked on the big task of reassessing the reserves quantitatively. For some mining districts precise estimates have been made, but it is considered that the aggregation of all the figures available would be misleading since they would combine estimates varying widely in reliability. Undoubtedly there are extensive reserves of coal available in the country as a whole, but some of the long-worked parts of the fields are becoming, or have been, exhausted of coal which can be worked economically. Full assessments of the concealed extensions to some coalfields have yet to be made and in some instances the details will not be available until mining developments have actually encroached on these virgin areas. As shown by the exceptional structural difficulties encountered in parts of the South Wales and Scottish coalfields

1. Particularly stupid and confusing is the use by the Ministry of Fuel and Power of the term 'North-eastern field' meaning in fact west and south Yorkshire.

a network of boreholes of normal density does not always provide a reliable picture of the actual mining conditions likely to be encountered. The conditions under which mining, even with modern methods, can be carried out economically are relatively narrow. Emphasis must be laid on the fact that much of the best coal, and of the coal which is cheapest to work, has gone. In many areas, therefore, technical advances in mining methods are largely offset by greater physical difficulties of extraction.

In the general estimate of reserves previously quoted the Coal Survey Officers usually disregarded seams lying at depths below 1200 metres (4000 ft) (this was extended to 1350 metres in the case of a few collieries in South Lancashire and North Staffordshire). In some coalfields deep mining could well be extended appreciably below 1200 metres, but in highly disturbed coalfields, like that of South Wales, poor roof and floor conditions over wide areas will not permit mechanised mining even well short of these levels. On a conservative estimate it would appear that Britain has sufficient coal for upwards of 200 years at the present rate of extraction. Whether this will be fully required is open to questioning in the light of developments in the production of other forms of energy. It must be again stressed that the reserves are not shared equally on a unit area basis between the separate coalfields; in some fields economic exhaustion is in sight. Comparison with other European countries will nevertheless show that only Germany (pre-1939 frontiers) is so well endowed with coal resources.

## The classification of British coals

British coals include substantial reserves of anthracite in the northwestern quadrant of the South Wales coalfield and minor quantities of this comparatively rare coal in Ayrshire; the remainder are bituminous or humic coals. It has long been the custom to use a rough classification into types based on the suitability of the coals for different purposes. Thus steam coals are hard, burn with little flame and little soot and were therefore much valued for bunker purposes and for ships. Similar types are appreciated for some domestic purposes under the name of 'kitchen nuts' when broken to a small size, and are suitable for consumption in enclosed stoves. By way of contrast, household coals, those which are favoured for burning in open grates, still to be found in English homes, are coals which give a pleasant flame, and are described by the housewife as being 'gassy'. Then the coking property of coals is important. Good coking coals should also, of course, yield a large supply of gas, and if the coke is required for the iron industry, it is essential that it should be a good hard coke, and should not crush when loaded with a considerable weight of iron ore above it. The relative absence of intense folding in the British Isles has resulted in the comparatively small proportion of powdered coals of the types extensively used on the continent of Europe for the manufacture of briquettes. It is indeed only in recent years that coal slack—dust—has been utilised at all in this country, and only a

few collieries have briquetting plant for this purpose. The coal dust requires to be mixed with some material, such as pitch, as a binding substance.

In recent years a more exact classification has been brought into use. This scheme was evolved by the Coal Survey officers to assist the Ministry of Fuel and Power in making a census of fuel consumption. The arbitrary 'code numbers' are based on content of volatile matter (on the dry ash-free basis) and coking properties.

I Low-volatile coals (volatile matter 20 per cent or less)
- 100 Anthracite: non-caking, volatile matter less than 10 per cent.
- 200 Low-volatile steam coals (types distinguished as 201, 202, 203, 204, 206).

II Medium-volatile coals (volatile matter 20.1–30.0 per cent).
- 300 Scottish medium-volatile, non-caking or weakly caking.
- 301 Coking coals, strongly caking. (These are the metallurgical coking coals of Durham and South Wales.)

III High-volatile coals (volatile matter over 30.0 per cent). (Each group is divided into 01 and 02, with respectively less and more than 37.0 per cent of volatile matter.)
- 400 Very strongly caking coals
- 500 Strongly caking coals
- 600 Medium caking coals
- 700 Weakly caking coals
- 800 Very weakly caking coals
- 900 Non-caking coals.

All coals have a certain proportion of ash and a high proportion is noticeable in some coal now being mined. It has been authoritatively stated that 2½ per cent should be deducted from post-1950 production to allow for the poorer coals compared with pre-1939 output.

## Coal type reserves in the separate fields

Although in need of considerable revision the table opposite (the only one available) gives some indication of the reserves of the various types of coal, as defined in the previous section, within Great Britain as a whole.

In the Northumberland and Durham field the change in the physical and chemical characters of any one seam when it is traced laterally is greater than the difference in seams higher or lower in the succession at a given locality. In Northumberland the predominant type is weakly caking (700), but medium and strongly caking coals (500 and 600) are available in appreciable amounts. The range of coals in the declining western half of the Durham coalfield is rather narrow; about half the production in the past has comprised the special coking coals (301 and 401a). The volatile content increases towards the east where they pass into coking-gas and gas coals (401, 501, 502). Northward they change into medium and weakly caking

coals (601, 702) marketed chiefly for power stations, general industrial use and house coal; they are of excellent quality.

Virtually the whole of the limited Cumberland coalfield production is of the high volatile strongly caking class (500).

In the West Yorkshire field types 500 and 600 predominate. More than 70 per cent of the production has come from five seams, but there has been a noticeable move eastward to the deeper part of the field and seams with other types of coal are likely to be worked. In the Sheffield area of South Yorkshire the dominant types are 500, 600 and 700; further south in Nottinghamshire they range on either side of 800 from very weakly caking to non-caking types. The progressive southward change continues into the fields of Leicestershire and South Derbyshire, where the coals are mainly non-caking (900), especially in seams of more than five feet thick. In the other Midland fields very weakly caking and non-caking coals (800–900) again predominate.

*Summary of developable coal reserves in Great Britain*[1]
(in millions of long tons)

| TYPE OF COAL | PLANNED OUTPUT 1942 2042 TONS | % | PROVED ADDITIONAL RESERVES TONS | % | OUTPUT 1938 TONS | % |
|---|---|---|---|---|---|---|
| Anthracite (100) | 704.6 | 3.4 | 914.3 | 6.8 | 6.1 | 2.7 |
| Steam coals (200, 300; low and medium volatile) | 1 861.9 | 9.1 | 1 306.6 | 9.8 | 20.7 | 9.1 |
| Coking coals (301, 401; medium volatile) | 1 556.2 | 7.6 | 1 130.5 | 8.5 | 20.7 | 9.1 |
| Coking-gas and gas coals (400, 500, 600; high volatile) | 7 402.3 | 36.1 | 3 953.5 | 29.5 | 85.0 | 36.8 |
| Household and industrial coals (700; high volatile, weakly caking) | 2 894.4 | 14.1 | 1 448.0 | 10.8 | 34.2 | 15.0 |
| Household and general coals (800, 900; high volatile, non-caking) | 5 634.1 | 27.5 | 4 623.8 | 34.6 | 60.7 | 26.6 |
| Unclassified | 446.9 | 2.2 | — | — | 1.8 | 0.7 |
| | 20 500.4 | 100.0 | 13 376.7[2] | 100.0 | 228.2 | 100.0 |

[1] Data from *Rapid Survey of Coal Reserves and Production*, Fuel Research Board, Dept of Scientific and Industrial Research, 1946.
[2] Exclusive of at least 2000 million tons unclassified.
1 long ton = 1.016 metric tons.

Apart from a small output of very strongly caking coal (301 and 400) from the Burnley basin, the coals produced in the Lancashire coalfield range from strongly caking (500) to non-caking, high-volatile types (900). In North Staffordshire the coals show, quite markedly, stronger caking pro-

perties with increasing depth. There has been a trend towards the production of larger quantities of very strongly caking coal (400) whilst in the southern concealed area, now being developed, medium-volatile caking coals occur at moderate depths.

South Wales coals range from 100 to 400; anthracite predominating in the northwest, dry steam coals (200) in the heart of the field, and medium or high-volatile coals, including the medium-volatile coking coals (301), towards the southeast. In the entirely concealed Kent field the chief reserves are also of type 200 and anthracites could possibly exist in the deeper seams beyond the eastern coastline.

Scotland has coals of very varied types. Though anthracite is absent, apart from the small quantities in Ayrshire, there are excellent steam coals and a wide range of high-volatile coals.

## Opencast working and drift mining

It may seem strange that during the Second World War, after more than a century of essentially deep mining, Britain returned to the open pit or opencast working of coal to such an extent that from 1944 onwards nearly 5 per cent of the production has been obtained in this way. A maximum output of 14.5 million metric tons (14.3 million long tons) was achieved in 1958; the 1968 production totalled 7.1 million metric tons (7 million long tons), the annual output having remained fairly stable around this mark since 1960. In exceptional cases opencast sites are now being worked to depths of more than 150 metres (500 ft). In many of the coalfields, areas of low dip are often defined by slopes of gentle grade at little variance with the underlying structure. Terrain of this type is ideal for opencast working since it often implies that where extractable seams are present the ratio of overburden to coal thickness remains at manageable proportions over extensive sites. Before the advent of opencast mining techniques much of this coal was too deep to quarry and too shallow to mine without giving rise to roof support or subsidence problems.

Large-scale mechanical excavators, dragline scrapers and bulldozers now make it possible to remove greater thickness of overburden and to do it economically. All opencast sites are carefully restored to their former, normally agricultural, usage. In recent years wherever opencast operations can be combined with the reclamation of derelict land the National Coal Board seek to plan and design these activities, in cooperation with local authorities and other bodies, so as to improve the environment of areas of opencast workings and to provide land for recreation or development. When opencast production was at its peak between 1947 and 1959 rather more than 60 per cent of each annual output was obtained from Northumberland, Durham, Yorkshire, Derbyshire and Nottinghamshire, where structural conditions are generally more favourable for opencast workings than in the other coalfields. Stocks of opencast coal remained at a high level

during 1968 and the National Coal Board decided that for the time being, at least, production from new sites should be kept at a minimum consistent with supplying market needs and maintaining opencast potential. The Ministry of Power's White Paper on Fuel Policy stated that further authorisations for opencast production would only be given where, because of quality or location the coal produced would not be in competition with deep-mined output. Thus in the western half of the North Crop of the South Wales coalfield the opencast production of anthracite, which reached a peak level of 1 635 000 metric tons (1 610 000 long tons) in 1966, is being maintained at a high rate.

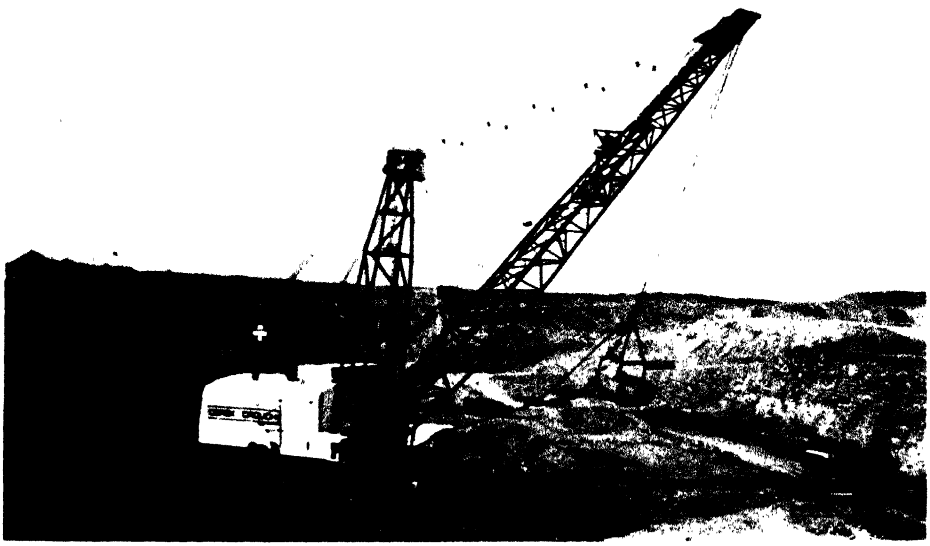


PLATE 10. Opencast coalmine in Northumberland. The huge walking dragline, made by Bucyrus-Erie in Milwaukee, USA, weighs nearly 3000 tons and has a 65 cubic yard capacity bucket (compare the size of the lorry and coach); it can shift 2600 cubic yards of overburden in an hour

Much of the high cost of opencast coal workings in the war years may be attributed to its experimental nature; opencast mining is now a highly profitable operation. Thus in 1967–68 the National Coal Board's deep mines made an operating profit of only 2*s* 9*d* per ton as compared with 18*s* 6*d* per ton for its opencast operations. Initially it was feared that much of the coal might be badly weathered and consequently of poor quality, but now with it being feasible to work to much deeper levels these doubts are to a large degree no longer valid. Past speculations on the likely period of life of future opencast operations have invariably been proved wrong; they

seem likely to continue for some years in the Durham and Northumberland, South Wales and Scottish coalfields where there has been an accelerated rundown of conventional mining. Small drift mines, normally employing less than twenty men apiece and operating under licence from the National Coal Board, produced 1.03 million metric tons (1.02 million long tons) of coal in 1967–68, a slight reduction on the 1966–67 output. The success of quite a few of these small units and the difficulties which had beset some of the National Coal Board's new deep mines has resulted in some change of policy with regard to the establishment of new drift mines by the Board. In the past eight years or so several new drift mines, usually employing between 100 and 300 men and directed at the exploitation of relatively shallow-lying reserves not likely to last more than twenty years, have been opened up, more particularly in South Wales, Scotland and the Burnley area of Lancashire. Production-wise many of these have been a great success.

It is perhaps of interest to note the introduction of a modified form of drift mining within a pit near the South Crop of the South Wales coalfield. Horizon mining, widely adopted in some west European coalfields, was introduced into this area in an attempt to work, on a large scale, the strongly dipping seams of high-grade coking coal. As the name implies horizon mining is a system whereby all seams are extracted between horizontal planes which form the main roadways. The incidence of thrust-faulting and disturbed ground was found to be on a much greater scale than originally envisaged whilst there was also some deterioration in seam quality. Horizon mining on a grand scale has therefore been abandoned and replaced by deep-lying drift mining which utilises the facilities provided by vertical shafts and horizontal roadways.

## The principal fields

### Northumberland and Durham

The Coal Measures in Northumberland and Durham dip away from the Pennine upland and eventually pass under the waters of the North Sea. In eastern Durham they are unconformably overlain by Permian beds, comprising, in upward succession, the Basal Permian Sands, Magnesian Limestone and Upper Permian Marl and reaching a maximum thickness of some 488 metres (1600 ft) in the coastal area near West Hartlepool. The older, shallower workings of the coalfield are thus situated on the flanks of the Pennines in the west whilst the larger and deeper modern collieries are nearly all to the east. In the concealed eastern section of the Durham coalfield much of the production is now being obtained from beneath a considerable thickness of the overlying Permian. The beds of this formation are generally water-bearing and this imposes limitations on the extraction of any coal seams lying immediately below. Percolating water from this

source has sometimes exceeded pumping capacity and led to the flooding and abandonment of collieries in the past. Thus mining less than 45.6 metres (150 ft) from water-bearing strata is now prohibited by statute unless it can be shown that the hazard has been overcome.

*The relative importance of Britain's coalfields*

| MINIMUM PROVED RESERVES | FIELD | YEARLY AVERAGE OUTPUT IN MILLION LONG TONS[1] | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1909–13 | 1922–4 | 1931–5 | 1950 | 1960–1 | 1967–8 |
| 1 537 | Ayrshire | 4.1 | 4.5 | 3.9 | 3.5 | 3.7 | 3.2 |
| 3 049 | Lanarkshire | 17.4 | 19.4 | 13.6 | 8.5 | 6.3 | 4.8[4] |
| 2 500 | Midlothian | 6.1 | 4.4 | 4.7 | 3.9 | 3.4 | 3.3 |
| 3 742 | Fifeshire | 8.8 | 8.5 | 7.8 | 7.3 | 4.0 | 2.7 |
| 5 510 | Northumberland | 14.0 | 13.7 | 13.0 | 12.1 | 10.9 | 8.8 |
| 870 | Durham | 40.4 | 36.6 | 29.3 | 26.5 | 22.5 | 17.8 |
| 1 528 | Cumberland | 2.2 | 2.2 | 1.5 | 1.1 | 0.9 | 0.6 |
| 26 000 | Yorkshire | 39.0 | 64.7 | 39.3 | 32.6 | 34.4 | 38.0 |
| | Notts and Derby | 31.5 | 30.2 | 26.6 | 36.3 | 42.6 | 39.2 |
| 4 367 | North Staffordshire | 13.9 | 6.3 | 5.9 | 11.0[3] | 8.9[3] | 9.5[3] |
| 1 415 | South Staffordshire | | 1.5 | 6.2 | 0.9 | 1.1 | – |
| 1 825 | Leicestershire | –[2] | 3.1 | 2.4 | 3.8 | 6.7 | 7.6[5] |
| 1 127 | Warwickshire | [2] | 5.1 | 5.0 | 5.1 | 3.9 | 3.3 |
| 4 239 | Lancashire | 27.3 | 19.2 | 13.7 | 12.5 | 10.3 | 7.9 |
| 1 736 | North Wales | | 3.2 | 2.8 | 2.2 | 1.8 | 1.3 |
| 26 000 | South Wales | 51.2 | 52.3 | 35.3 | 23.0 | 17.9 | 15.8 |
| 259 | Forest of Dean | [2] | 1.3 | 1.2 | 0.8 | — | — |
| 4 198 | Bristol and Somerset | 2.7 | 1.3 | 0.9 | 0.5 | 0.5 | 0.3 |
| 2 000 | East Kent | [2] | 0.4 | 1.9 | 1.7 | 1.4 | 1.45 |
| | Shropshire | | | — | — | – | 0.5 |

[1] 1 long ton = 1.016 metric tons. [2] Details not available. [3] Includes Cannock.
[4] Including extensions of field into adjoining counties. [5] Including South Derbyshire.

Along the Northumbrian coast many of the coal seams run uninterruptedly out to sea and 6.4 kilometres (four miles) from the coast may be taken as the economic limit for the working of the coalfield. Off the concealed section of the Durham coalfield a programme of undersea deep drilling to ascertain reserves and future mining potential was commenced in 1958. This has established the fact that large areas of thick coal lie ahead of existing coastal workings in several seams. Some seams previously thought to be too thin to exploit have proved to be of workable thickness whilst of equal significance the bore holes have revealed the existence of a thick bed of impervious rock overlying the coal seams and protecting them against possible future inflows of water. New undersea reserves of at least 500 million metric tons have been proved.

The Lower Coal Measures, that is those exposed in the extreme western part of the field, contain a few thin but workable coals. The productive measures of the field begin with the Brockwell or Denton Low Main Coal

and contain altogether about twenty-three workable coals. Many of the seams rest on beds of valuable fireclay or seat earth, formerly extensively used for the manufacture of firebricks. Amongst the best known coals are the Hutton and Low Main; the latter is a good gas and house coal in Durham, but north of the Tyne becomes a steam coal. Higher up is the

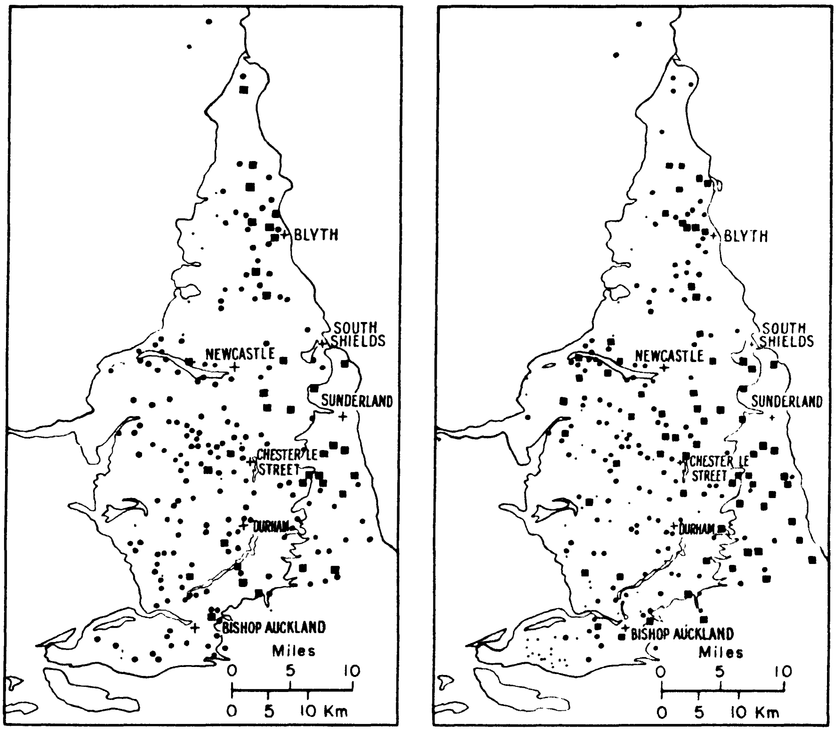



FIG. 115. The Northumberland and Durham Coalfield in 1900 and 1931

The square dots represent collieries employing more than 1000 men: the large round dots, collieries employing between 100 and 1000 men; the small dots collieries employing less than 100 The thin black line shows the limits of the *exposed* coalfield It should be noted that in 1900 there were only 11 large collieries in the hidden coalfield, in 1931 the number had increased to 20

famous High Main of South Northumberland, known also as the Wallsend Coal and utilised largely for household purposes; it was from 1.8 to just over 2 metres (six to seven ft) thick, but is now very largely exhausted. Durham coals exhibit a wide range of rank, quality and physical characteristics ranging from soft bright coking coals containing less than 30 per cent of volatile matter to hard, rather dull coals with greater than 36 per cent. These include some of the best coking and gas coals in the kingdom although other seams are much more suitable for household coal. North of the Tyne steam coals become prevalent.

Two sections given here (Figs 116 and 117) show the general disposition of the coal seams and the way in which the Coal Measures are slightly

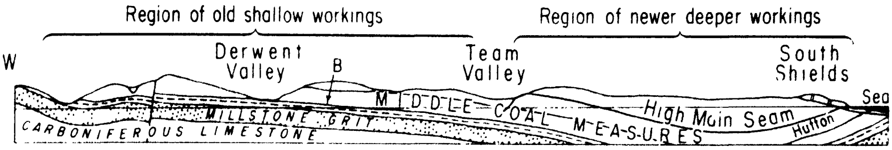



FIG. 116. Section across the northern part of the Durham field (just south of the Tyne), showing the valleys which facilitated the early working of coal. B = Brockwell Seam (after Walcot Gibson)

folded under the cover of the Magnesian Limestone and associated Permian beds. Numerous faults and dykes of igneous rocks cross the field, usually in an east and west direction. The Ludworth Dyke, which pre-dates the Permian rocks, traverses the full width of the concealed coalfield to the east of Durham City. It is encountered in the workings of a number of collieries and has had a severe metamorphic effect on the coal on both its flanks. In places low-volatile, heat-altered coals extend for about three-quarters of a mile on either side of the dyke in all seams being mined. Two of the best known faults are the Butter Knowle in South Durham, with a throw of between 73 and 129 metres (240 and 420 ft), and the famous Ninety Fathoms Fault which in places shifts the Coal Measures no less than 300 metres (1000 ft). The Butter Knowle Fault running eastward for some eight miles from near Ferryhill to the coast just north of Hartlepool separates two areas of contrasted structural aspect within the concealed coalfield of East Durham. To the north folding is gentle, but to the south sharper folds with closures of several hundreds of metres are aligned with their axes parallel to this major fault.

The Carboniferous Limestone Series is exposed to the north and west of the Coal Measures and, as in Scotland, this contains in Northumberland some workable coals. Two collieries to the south of Alnwick and one to the west of Hexham were exploiting seams in this formation in 1968.

The three maps shown in Figs 115 and 118 show the location and size of individual collieries in 1900 compared with those in 1931 and 1968 and demonstrate very clearly how the main weight of mining activity has continued to move eastward during the present century. In the exposed section of the Durham coalfield most of the better-quality seams were worked out from many small shafts and surface adits before or during the nineteenth

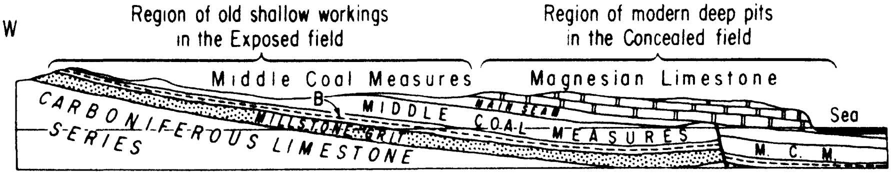



FIG. 117. Section across the southern part of the Durham field, showing the thick mass of Magnesian Limestone covering the concealed coalfield. B = Brockwell Seam (after Walcot Gibson)

century. Mining in the shallower or western sector of the concealed coalfield has now declined appreciably and in the future a still greater proportion of the output will be derived from the relatively small number of large modern collieries operating beneath the coastal and undersea areas to the south of Sunderland.

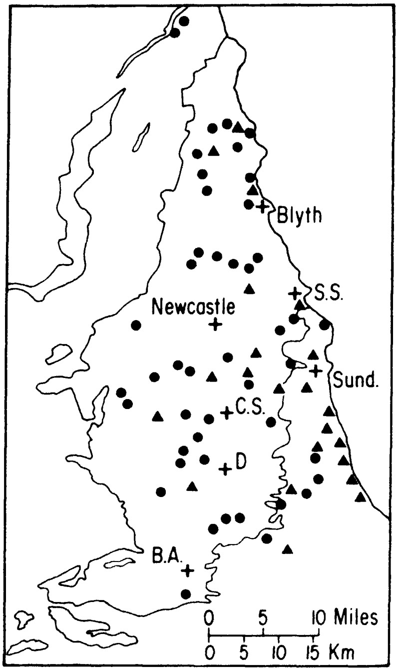



FIG. 118. The Northumberland and Durham coalfield, 1968

Round symbols, mines employing between 100 and 1000 men; triangles, over 1000 men

Coal mining in the Northumberland and Durham coalfield began at a very early date, and from the fourteenth century 'sea-cole' was shipped from the Tyne and Wear to London. This coal was either picked up on the seashore or obtained from sloping tunnels driven into the sides of the incised valleys of the major rivers, and carried from the mine entrances to navigable water by packhorses. The use of wheeled vehicles on the primitive roadways was rendered difficult by the thick and sticky boulder clay surface of the plateau, and wooden tracks or 'corduroy roads' were laid down, later to be replaced by wooden rails, then by flanged cast iron rails and lastly by rails on which ran vehicles with flanged wheels. Sometimes the loaded coal waggons descended by gravity and pulled up at the same time the empty ones; in other cases the waggons were horsedrawn. The railway had evolved itself; it merely awaited the coming of the steam locomotive. Some of these

early waggonways are shown on Fig. 119. The Stockton and Darlington Railway of 1825, with its locomotive haulage, solved the problem of coal transport to the Tees; within a few years it was extended to Middlesbrough and Hartlepool, and numerous coal-carrying railways were constructed, especially in the Durham section of the coalfield and in south Northumberland, leading from the mines to the staithes (wooden piers) from which the waiting seagoing colliers could be loaded.

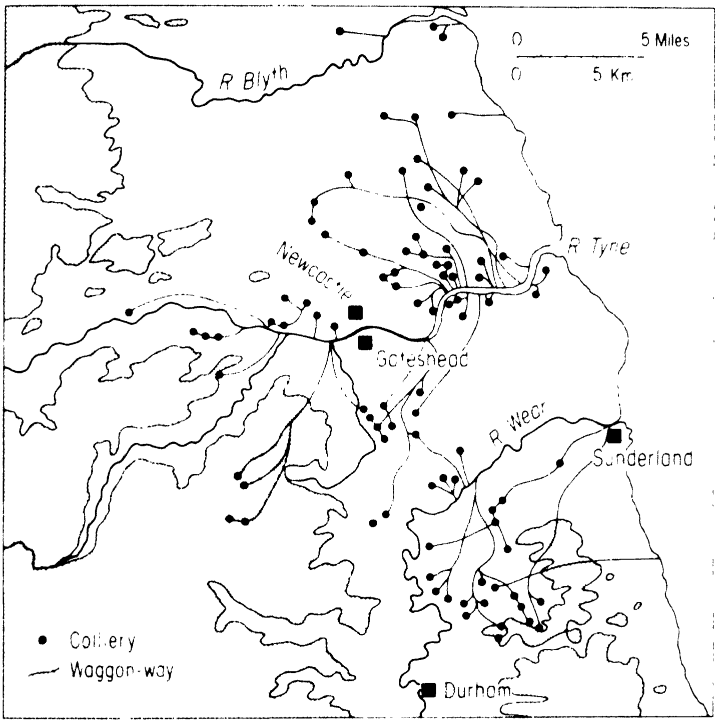



FIG. 119. Old waggonways and collieries, Northumberland and Durham field, 1830, showing the importance of access from navigable water (after Rodwell Jones). Land over 400 ft, stippled

This coalfield is, indeed, more conveniently situated for the export of coal by sea than any other large English field. Hence it is not surprising that in the interwar years 35 per cent of all the coal mined was exported. A substantial proportion of the current production is still carried by coasting vessels to other parts of Britain, and more particularly to Thameside. Because of its former dependence upon the export trade, the Northumberland–Durham coalfield felt the effects of the post-1920 depression more than any other field in the country. In this respect its fortunes compared with those of the South Wales coalfield. Since 1960 the general rundown of the coal mining industry and the concentration of activity at the larger or reconstructed units has given rise to the accelerated closure of dozens of

small collieries in the western half of the exposed coalfield. Here a high proportion of the remaining reserves of the thicker seams is situated in the takes of long-abandoned workings or was too far removed from the outlets or shafts of the recently closed units to allow viable extractive operations. Many mining villages to the west and northwest of Newcastle, near Consett and in the vicinity of Bishop Auckland, have been denuded of their active collieries. In the latter town, in particular, a traditional centre for the mining of first-rate coking coal—perhaps the best of all coking coals for the iron smelting industry—this has had serious economic and social consequences for which there are no easy solutions. Some former mining villages will surely die slowly; others will merely become dormitory centres for commuters finding alternative employment in the more accessible large centres of population with a more varied industrial structure. In 1959 the Northumberland and Durham coalfield produced 34.5 million metric tons (34.4 million long tons) of saleable coal from 164 National Coal Board collieries. A production of 27 million metric tons (26 million long tons) during the year ended 30 March 1968 was forthcoming from seventy such units.

## Cumberland

Though only a small field, the Cumberland coalfield resembles that on the other side of the Pennines by the way in which the Coal Measures run under the sea, but this time west and northwestwards under the waters of the Irish

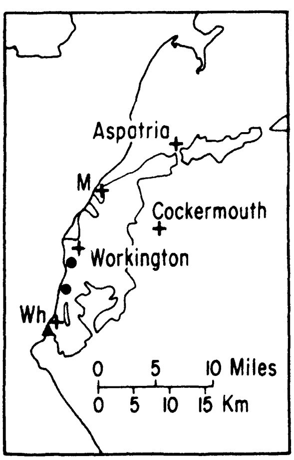



FIG. 120. The Cumberland coalfield, 1968
For symbols see Fig. 118.

Sea and the Solway Firth. In 1968 there were only three productive collieries, all situated on or near the coastline between Workington and St Bees Head. The workings extend for a substantial distance—up to a limit of

about 6 kilometres (four miles)—under the sea, the limit being determined approximately by the cost of haulage from the working faces to the shafts, which of necessity, must remain on land. In addition to the exposed area and the area under the sea, there is a small extension of the coalfield under younger rocks towards the south, but a much larger extension to the north of Aspatria, where the Coal Measures are covered by Triassic rocks. It is probable that the Coal Measures extend right underneath the lowlands of the Solway marshes or the Carlisle Basin and reappear as the tiny Canonbie coalfield situated some distance to the north of Carlisle, that is towards the west and northwest. There are numerous faults, with throws of from 91 to 183 metres (300 to 600 ft), running from northwest to southeast across the coalfield, and the northern edge of the worked field in Cumberland is terminated by a complicated belt of fracture. The detailed structure to the north of this belt has not been fully determined, but it now seems unlikely that any coal reserves beneath the Solway lowlands will be exploited. In 1968 the three active collieries within this field had a combined labour force of nearly 3000. Two out of the three collieries had productivity rates of less than half the British average, and it is possible that a complete cessation of coal mining activities is not too far away.

## Lancashire and Cheshire

On a geological map the Lancashire coalfield appears as a triangular patch of exposed Coal Measures lying to the west of the Millstone Grit and older rocks of the Pennines. In the heart of the exposed Coal Measures, inliers of considerable extent of Millstone Grit define the general trend of the Rossendale Anticline. The Lower Coal Measures succeeding the Millstone Grit are between 420 and 800 metres (1400 and 2600 ft) thick. They are widely exposed within the coalfield, but are rather poor in coals. Most of the productive and thicker coals occur within the Middle Coal Measures which are of more restricted distribution. The main weight of coal mining activity within the Lancashire coalfield has therefore been concentrated on zones of rather limited area extent. Three such coal mining zones are normally recognised.

(*a*) *The Burnley coalfield.* The Burnley basin of Middle Coal Measures is a broad synclinal tract lying between the Pendle Monocline to the northwest, the Rossendale Anticline to the south and the Pennine Anticline to the east. The continuity of its component coal seams is much disrupted by thrusts, slides and tear faults, mostly with a northwest to southeast or westnorthwest to eastsoutheast trend. Within the northern half of this basin much of the coal has been exhausted and the only important seam remaining unworked at depth over a substantial area is the Lower Mountain (Union). At the beginning of 1968 the southern half of the Burnley basin contained six active mines. Four of these had productivity rates of more than 1.8 metric

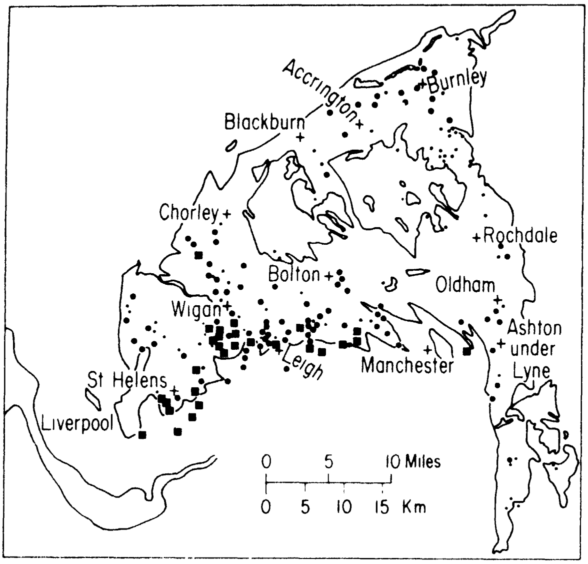



FIG. 121. The Lancashire Coalfield, 1931

tons (36 cwt) per manshift, which was well above the average for the Lancashire coalfield, and this is largely a reflection of the economic viability of drift mining at relatively shallow depths. The Upper Mountain and the Lower Mountain were the main seams being worked, but at a few of these drifts accessible reserves were quickly being exhausted.

(*b*) *The South Lancashire coalfield.* In the south the rocks of the Middle Coal Measures, which succeed those of the Lower Coal Measures and Millstone Grit lying to the north, have a rather steep dip and are quickly concealed by a cover of Triassic rocks. Here is to be found probably the maximum thickness reached by Coal Measure rocks in the British Isles, but unfortunately the southerly dip of the beds increases as they pass under the Triassic cover and thus the concealed coalfield has economically a limited extent towards the south. Even so, the workings of the larger collieries have in places extended to depths of more than 1200 metres (4000 ft) and are the deepest in the British Isles. It is probable that the Coal Measures underlie the whole of the Triassic Plain of Cheshire and are connected directly with the fields of North Wales and North Staffordshire. Oil companies are still interested in the possibilities of discovering new sources of hydrocarbons within any suitable buried structures occurring beneath the Triassic cover rocks, but maybe one should eliminate any thought of future coal mining operations at these depths.

The curiously irregular southern edge of the exposed measures in south Lancashire is due to the numerous and large faults which cut across the Coal Measures in a direction roughly from northwest to southeast. Further east, in the Manchester coalfield the faults assume a more north to south

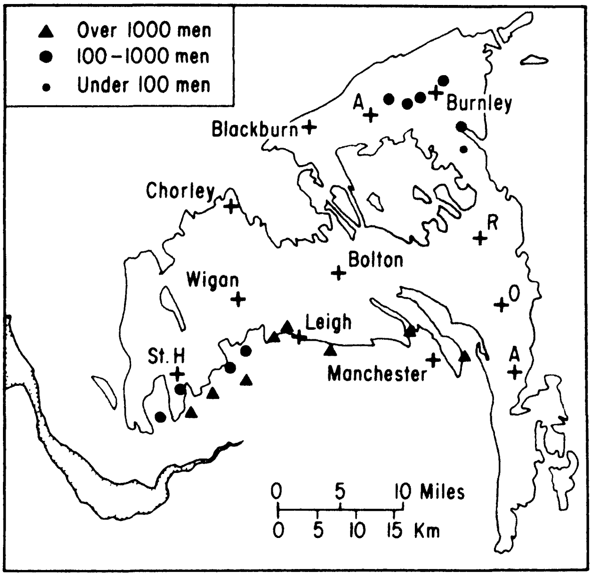



FIG. 122. The Lancashire coalfield, 1968

trend. The Irwell Valley Fault has an estimated throw of 900 metres (3000 ft) in places whilst east of this the Bradford Fault has given rise to a vertical displacement of something like 500 metres (1800 ft) so that one cannot overstress the serious dislocations to the continuity of large-scale mining operations brought about by the presence of such faults. As in so many of our coalfields, the greater part of the faulting took place before the deposition of the succeeding rocks of the Permian period and represents fracturing which was occasioned by the Armorican earth movements (see p. 15). Amongst the famous and important seams of this field, which have been extensively worked, are the Wigan 9-ft, the Arley and Yard coals. In the Wigan district the well-known Wigan cannel coal (a corruption of 'candle' coal because splinters, when lit by a match, will burn with a flame like a candle) overlies the King coal. But this curious coal, which is of rather limited distribution elsewhere in Britain, is now practically exhausted. Its character is believed to be due to a difference in the mother substance of the coal, since it has been found to consist mainly of the spores of the seed-bearing organs of the ancient tree ferns which have gone to make up ordinary coals.

If one includes the two major pits within the built-up area of Manchester, the South Lancashire coalfield contained twelve productive collieries in 1968. The majority of these were large concerns with individual mining complements of more than 1000. They included the new pits of Agecroft, in the northwestern suburbs of Manchester, and Parkside, at Newton-le-Willows. Capital expenditure on these two new pits was more than £10m and £14m, respectively. Agecroft colliery produced 711 000 metric tons

(700 000 long tons) of saleable coal in 1968 with a productivity level approaching 2 metric tons (40 cwt) per manshift. On the other hand Bradford colliery located four miles to the east yielded only 406 000 metric tons (400 000 long tons) despite a £6m major reconstruction scheme, following which its output was expected to rise to 1 million metric tons per annum.

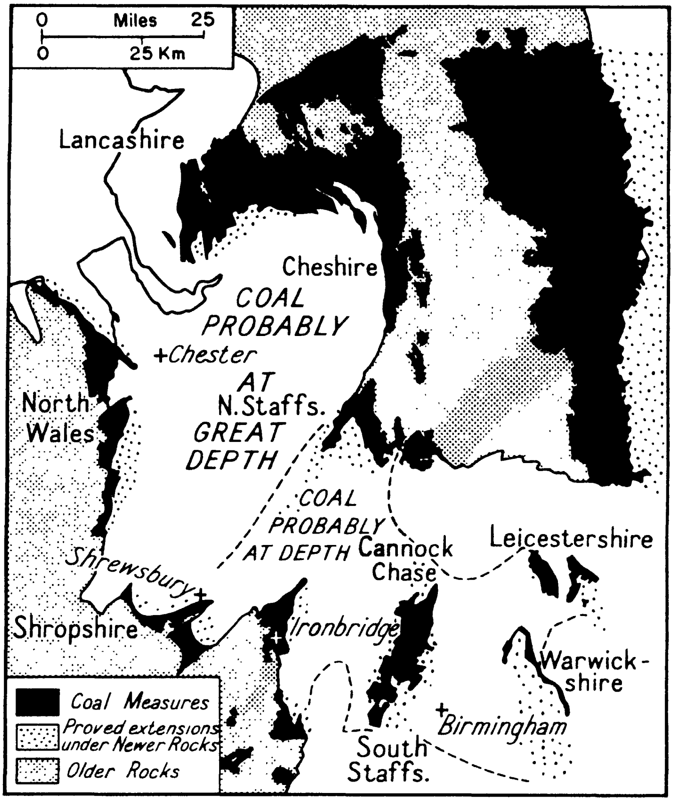



FIG. 123. The exposed and hidden coalfields of the Midlands, and their relationship to one another

(*c*) *The Manchester coalfield.* The southeastern prolongation of the Lancashire coalfield lying east of Manchester and running southward through Ashton under Lyne and Stockport towards Macclesfield is commonly known as the Manchester coalfield. In 1968 it contained no active colliery. Not unexpectedly the Coal Measures in this area can be correlated with those of North Staffordshire to the south, while it is possible to recognise correlatives of some of the seams of the Yorkshire coalfield on the far side of the Pennines, and there is little doubt that the Coal Measures were originally deposited continuously across the area now occupied by the Pennine Uplift. The combined thickness of the Middle and Lower Coal Measures within this coalfield exceeds 1500 metres (5000 ft) and no less than twenty-three seams

have been worked in the past. The reserves within this field are by no means exhausted, but in addition to an adverse economic climate the need to pump out large quantities of water from some of the mines hastened their closure. In the concealed segments to the west all the main seams are likely to be present at depth, but despite the presence of several large faults, which throw against the westerly dip and bring the measures nearer to the surface on their western sides, future mining would most likely prove uneconomic.

### The North Staffordshire or Potteries coalfield

At its southern end the western margin of the Pennine Uplift is marked by the existence of a number of sharp folds. In the western, and by far the deepest fold, the Coal Measure sequence is preserved intact. In the Cheadle basin very much less remains, whilst farther north only the lowest and least

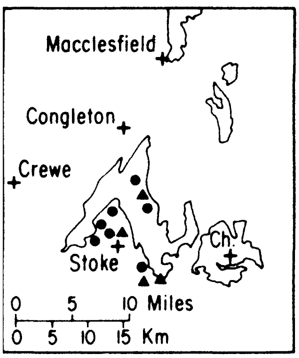



FIG. 124. The North Staffordshire or Potteries coalfield, 1968
For symbols see Fig. 118.

productive parts of the Coal Measures have escaped denudation in the shallow troughs amongst the older Carboniferous rocks. Thus the North Staffordshire coalfield is characterised by extensive folding and faulting of the Coal Measures. The most important coals occur in the Middle Coal Measures. There are some coals in the Lower Coal Measures, but in the Upper Coal Measures, apart from the lower group (Blackband Group), the rocks become reddish and barren, and are held by some to indicate the on-coming of desert conditions towards the close of the Coal Measure period in the British Isles. It is estimated that in 1200 metres (4000 ft) of strata the coalfield contains an aggregate of 42.6 metres (140 ft) of coal in thirty seams of over 60 centimetres (about two ft) in thickness, vertically distributed in such a manner as to permit most of them being worked by one pit at any one place.

The coalfield is especially important because numerous seams of good quality are well adapted to the requirements of the industries which have been established in the field. The potteries, however, no longer use the

'long-flame' coal that was so important to them in the past (cf. p. 602). In the west there are some good gas and coking coals (400 to 800 types). These are now largely worked out, but coking coals are being obtained from deeper seams in the centre of the syncline whilst reserves, only recently tapped, exist in the concealed southern extension of the field. Fireclays are still important in this field, but the formerly valuable ironstones are no longer worked.

In 1958 the North Staffordshire coalfield had twenty productive collieries. By 1968 this number had been reduced to eleven which were all concentrated within, or on the outskirts of, Stoke-on-Trent and Newcastle-under-Lyme. In the late 1950s and early 1960s no less than £27m was spent by the National Coal Board on the reconstruction of three of the larger collieries. It is gratifying to note that in 1968 one of these pits produced more than 1 million metric tons of saleable coal whilst at two of the collieries output per manshift was well above the British average at more than 2.5 metric tons (50 cwt) per manshift (overall).

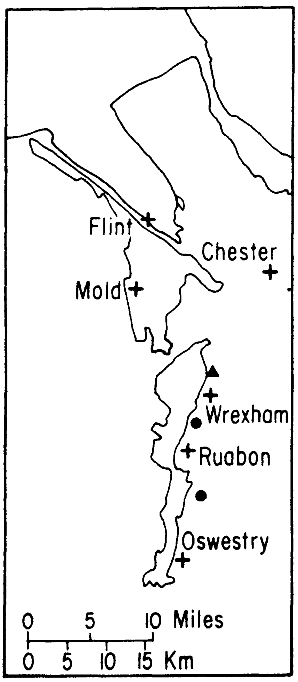



FIG. 125. The North Wales coalfield, 1968
For symbols see Fig. 118.

## The North Wales coalfield

This coalfield may be taken next because it represents the western exposed portion of the huge basin which probably underlies Cheshire (Fig. 123).

The Carboniferous rocks rest unconformably on highly folded ancient sediments of the Ordovician and Silurian periods, indicating that the Welsh massif formed a land mass at the time of the deposition of the Coal Measures. So much of the Coal Measures is covered by superficial deposits, in the form of thick glacial sands and gravels and estuarine or river alluvium on Deeside, that the structure is known only as the result of mining. A huge fracture running from westsouthwest to eastnortheast, a continuation of the major Bala Fault, divides the field approximately into a northern, or Flintshire, portion and a southern, or Denbighshire, portion. Some of the most important coals are steam coals (200 types), but in addition there are house and gas coals. Beneath the Triassic cover to the east, the coalfield has been worked in the southern part of the Wirral peninsula; borings show that the concealed segments of the field have a very complicated structure with several major faults, many of which run roughly parallel to the general trend of the exposed field to the west.

None of the collieries within this field have ever shown high productivity rates and in 1968 there were only four active units along its 64 kilometre (40-mile) length.

### The Shrewsbury or Central Shropshire coalfield

This little field with its three seams, having a total thickness of two metres (six feet), may be mentioned here because it seems to represent the southernmost extension of the Cheshire basin and the Coal Measures are resting on the ancient rocks of the Welsh massif. Old rocks occupy the whole area southward.

### The Yorkshire, Nottinghamshire and Derbyshire coalfield

While it has been common practice to regard as three fields those of West Yorkshire, South Yorkshire and Nottinghamshire and Derbyshire, in reality the three form one huge coalfield with a common geological structure and containing for the most part the same types of coal though changing gradually from 500 types in the north to 900 in the south. The whole area, it is true, is divisible into a western exposed coalfield and an eastern concealed coalfield where the Coal Measures are covered by an easterly-thickening sequence of Permian, Trias and later rocks. There is a certain geographical distinction between the three areas; the West Yorkshire coalfield has been particularly associated with the woollen manufacturing area around centres at Leeds, Bradford and Huddersfield; the South Yorkshire coalfield contains the steel and engineering industries of Sheffield and Rotherham; whilst the Derbyshire and Nottinghamshire coalfield shows more dispersed industrial centres, as at Nottingham, Chesterfield and Mansfield. The precise limits of the concealed coalfield are still not definable despite the continued programme of exploration for natural gas and oil;

but the known area of the whole field, exposed and concealed, is likely to exceed 6475 square kilometres (2500 square miles) or more than twice the size of the South Wales coalfield, and the field as a whole undoubtedly has the greatest reserves of any British field, exceeding in this respect even the

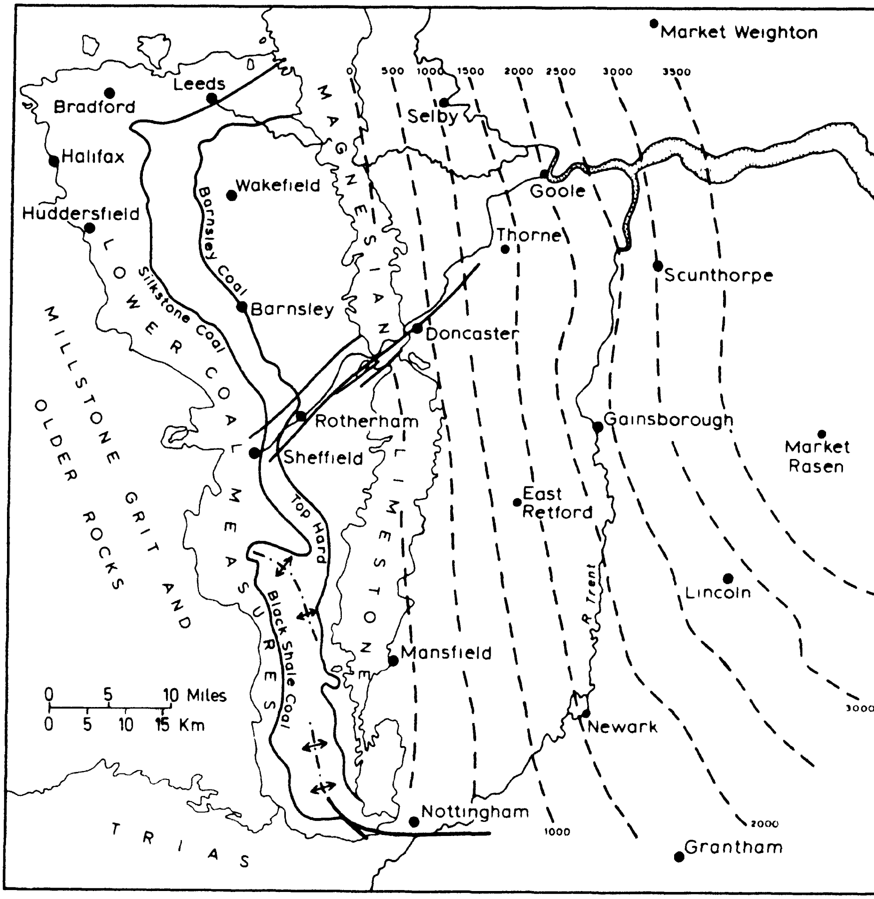



FIG. 126. Map showing the extent and major structural features of the Yorkshire, Nottinghamshire and Derbyshire coalfield

Note in particular the Don 'graben', the anticlines in the exposed Derbyshire section, and the considerable eastward extension beyond the river Trent (depths in feet)

rich South Wales field. The Coal Measures of the fields on the eastern side of the Pennines are less disturbed than those on the western side (Lancashire and North Staffordshire), and this is true of the great coalfield of Yorkshire, Nottingham and Derby. The Coal Measure rocks dip gently away from the Millstone Grit areas of the Pennine Uplift. Consequently there is a long band of Lower Coal Measures exposed in the extreme western part of the field. As usual in the Lower Coal Measures, the coals are on the whole few

and poor, but in Yorkshire the Ganister Coal has been extensively mined between Sheffield and Huddersfield, as well as around Halifax, though largely in connection with the underlying ganister and associated fireclays which afford high-class refractory materials of worldwide reputation. Then the Kilburn Coal of the Lower Coal Measures is famous as an almost ash-free house coal. This appears particularly in the southern part of the field and is scarcely recognisable in Yorkshire, where, however, around Bradford, Leeds, and Wakefield, the Better Bed Coal is one of great purity, and formerly much used for iron smelting. Around Leeds the Beeston coal, formed by the union of two coals, is occasionally as much as 2.5 metres (8 ft) thick, and is one of the most valuable seams in West Yorkshire. But on the whole it is the Middle Coal Measures which contain the most seams, and in which the formation of coal reaches its maximum development as regards thickness, quality, and the persistence of the individual seams. The famous Silkstone seam, the chief gas and coking coal, also well known as a house coal, is near the base of the Middle Coal Measures; whilst an almost equally famous seam, the Top Hard Coal of Nottinghamshire (known as the Barnsley coal in the Barnsley area) can be regarded as dividing the Middle Coal Measures into two parts. It is only in the extreme north of the field that the Barnsley coal deteriorates and passes into the Warren House coal. High dips amongst the coal seams are the exception in this great field, and are limited to a few restricted areas. Consequently mining operations are carried on with a greater facility than in any other British coalfield. As shown in the sectional diagram there are local anticlinal folds, especially in the south, and notably the Brimington anticline near Chesterfield and the Erewash anticline between Alfreton and Ilkeston, but on the whole faulting on an extensive scale is much less noticeable in this field than in most British fields. One of the most important groups of faults are those known as the Don faults, passing laterally into a monocline, and along this tectonic zone the Don itself runs.

As one passes eastwards into the concealed coalfield, the cover of Permian and Triassic rocks gradually increases in thickness, so that along the line of the River Trent there is an overlying thickness of more than 600 metres (2000 ft) of strata to be penetrated before the Coal Measures are reached. A boring at Market Weighton passed through 945 metres (3100 ft) of the cover rocks without reaching the Coal Measures. The structure of the explored sections of the concealed coalfield is by no means simple since this is given variation by a few shallow anticlinal folds between which the beds sag in wide troughs. A few of these anticlines are complex with subsidiary folds and may be flanked by substantial normal faults. With the notable exception of the buried northeastward continuation of the Don monocline of the exposed coalfield the trend of all these upfolds approximates more or less closely to the northwesterly strike of the Pre-Cambrian rocks of Charnwood Forest. Mention might be made of the Nocton–Blankey anticline, a large structure running southeastward from near

Lincoln; recent drilling indicates the presence of a further upfold at Stexwould, nine miles to the east. Within this highly important concealed coalfield the major structures discussed above are a deterrent to successful mining operations only in rather restricted zones. In this same context, the seams in the intervening wide troughs are liable to show minor flexures which may locally prove troublesome. It is of interest to note that the concealed Coal Measures lying southeast of a line drawn through Nottingham, Eakring and Lincoln contain bands of igneous rocks, most of which are of intrusive affinities, with olivine dolerites predominating.

The Upper Coal Measures occupy a very restricted area within this great coalfield, but this is of little consequence since the most important seams are

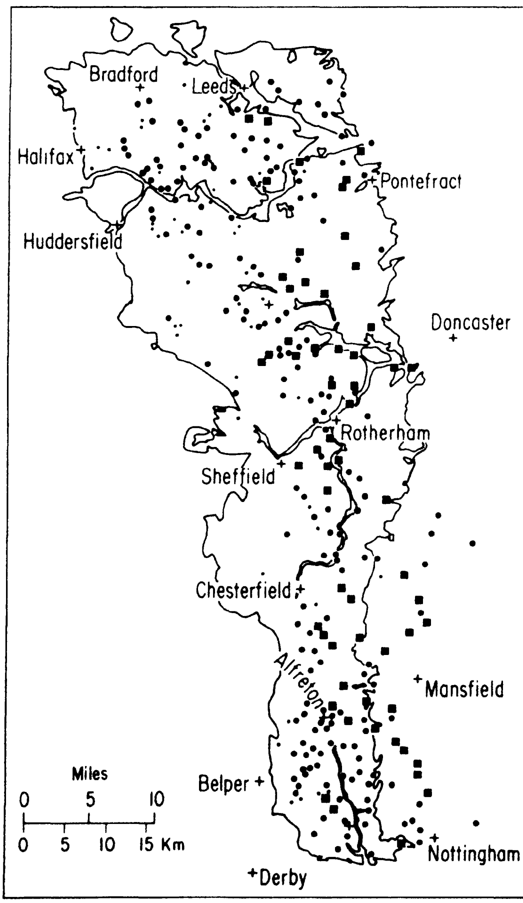



FIG. 127. The Yorkshire, Nottinghamshire and Derbyshire field, 1900

Square dots = collieries employing more than 1000 men. Large round dots = collieries employing 100 to 1000. Small dots = collieries employing less than 100. Note that there are only 11 large collieries in the hidden field.

in the Middle Coal Measures. Even if one includes only the area in which the valuable Barnsley or Top Hard coal has been proved in the concealed coalfield, it is found that this seam alone exists over 1555 square kilometres (600 square miles), and contains at least 2000 million metric tons of high-class coal within a depth of 900 metres (3000 ft) from the surface. The high

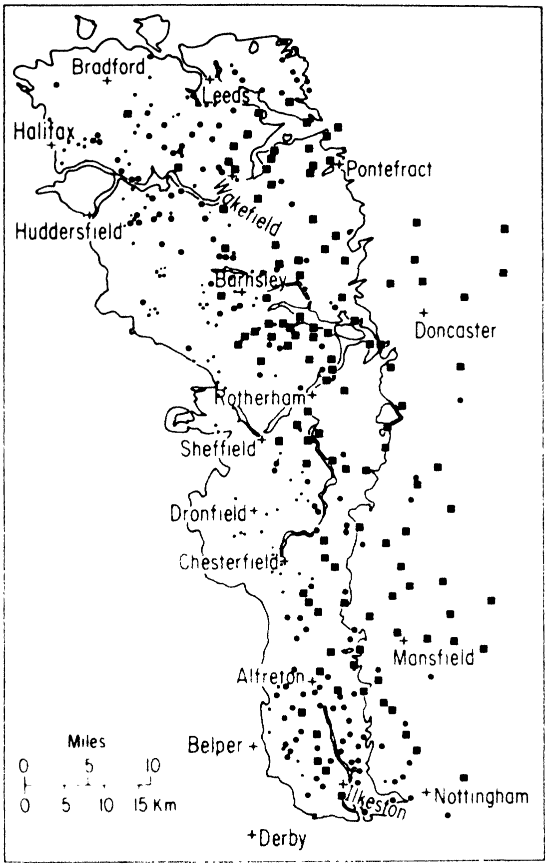



FIG. 128. The Yorkshire, Nottinghamshire and Derbyshire field, 1931

commercial value attached to this particular seam depends largely on the presence of a hard semi-anthracite coal known as 'hards' or 'hard coal', furnishing a really firstclass steam coal whilst other parts of the seam yield a house, manufacturing, and, to a lesser degree, gas coal. In Nottinghamshire this seam varies from a little under 1 metre (3 ft) to just over 1.8 metres (6 ft) in thickness, with an average for the proved area of 1.2 metres (4 ft) of good coal, whilst in Yorkshire an average thickness of 1.8 metres (6 ft) can be reckoned.

If one examines the three maps, Figs 127 to 129, showing the distribution

of collieries in the whole coalfield in the years 1900, 1931 and 1968, similar general trends to those noted in the case of the Northumberland and Durham coalfield will be observed. There has been a progressive movement of mining activity eastward, towards and into the concealed coalfield. Many of the older and smaller workings of the exposed coalfield, such as

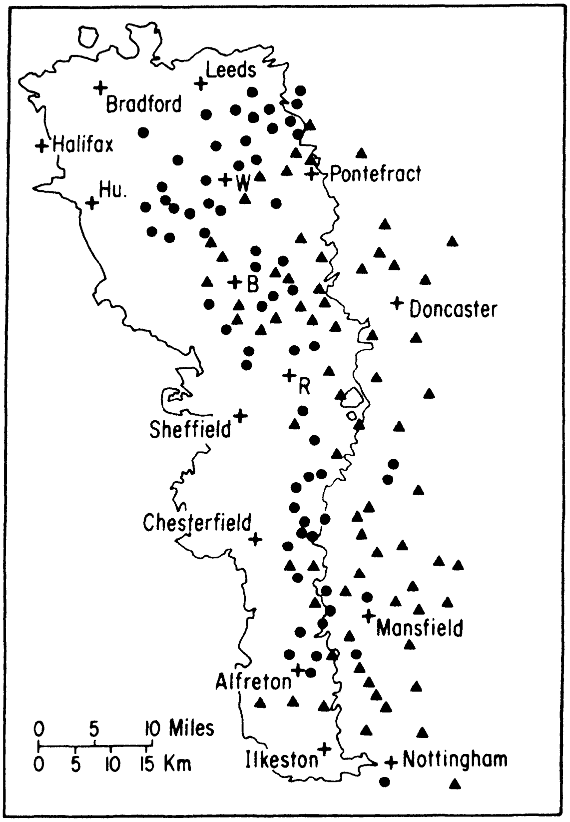
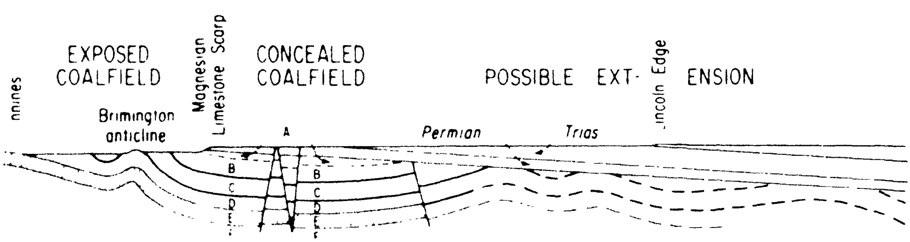



FIG. 129. The Yorkshire, Nottinghamshire and Derbyshire coalfield, 1968
Round symbols, 100 to 1000 men employed; triangles, over 1000 men

those lying west of Wakefield, Barnsley and Alfreton, respectively, have been closed down because the accessible seams have largely been exhausted and many of the working faces had advanced to locations too remote from the shafts or drift outlets. The concealed coalfield was not touched until 1859. Today it has more than thirty large modern collieries, as a group perhaps second to none in terms of efficiency and the development of modern mining practice. In distribution these collieries range southward in a broad belt between Doncaster, Worksop, Mansfield and Nottingham. Nearly all of these large collieries still have an employment roll of more than 1000 and

many of them record productivity levels of more than 3 metric tons (60 cwt) per manshift (overall), which is some 50 per cent above the British average. Three new pits have been sunk by the National Coal Board at individual costs ranging between £12m and £14m. These are Kellingley, lying east of Pontefract, Bevercotes, to the southeast of Worksop, and Cotgrave, located a few kilometres eastsoutheast of the built-up limits of Nottingham. Northeast of Kellingley colliery there are indications that considerable reserves of good-quality coal exist. Coal production began at Bevercotes colliery in February 1967. This is the world's first colliery planned for a complete and integrated system of remote and automatic control. Some initial difficulties were encountered in the operation of this, but when the colliery has been fully developed and its true potential realised, levels of productivity much in excess of the present national average should be attainable. Although a substantial number of working units have been closed or merged in the exposed section of the coalfield since 1960, many of the collieries here are operating at a profit and have large reserves for future working. A few new drift mines are within this category.




A Upper Measures
B Top hard Coal
C Main Productive Measures - Blackshale Coal
D Lower Coal Measures
E Millstone Grit
F Carboniferous Limestone

FIG. 130. Diagrammatic section from west to east across the Derbyshire–Nottinghamshire coalfield

This major Yorkshire, Nottinghamshire and Derbyshire coalfield yielded 80.6 million metric tons (79.4 million long tons) of saleable coal in 1959 (from 179 productive colliery units) out of an overall British total of 195.7 metric tons (192.6 million long tons) forthcoming from National Coal Board deep mines (41 per cent of the total). The corresponding figures for the year ending 30 March 1968 were 78.4 million metric tons (77.2 million long tons) in a national total of 165.3 million metric tons (162.7 million long tons) (47 per cent) from 133 producing collieries. One cannot overstress this increasing concentration of the British output of deep-mined coal on this important field, and more particularly on its newer concealed sections. It might be instructive, therefore, to view in rather more detail one of these concealed zones where relatively speaking, at least, coal mining has assumed greater significance. To the east of Mansfield nine large modern collieries produced 8 million metric tons of coal in 1968 at productivity rates up to

4.5 metric tons (90 cwt) per manshift (overall). The greater part of this output was forthcoming from the High Hazles, Top Hard, Deep Soft and Tupton or Low Main seams at depths ranging between 365 and 853 metres (1200 and 2800 ft) below the surface. The uppermost workings (that is in the High Hazles seam) varied between 150 and 300 metres (500 and 1000 ft) below the base of the unconformable cover of Permian and Triassic rocks which succeed the Coal Measures. All these coals are of a bituminous nature with 81 to 85 per cent of carbon and 36 to 47 per cent of volatile matter. They are largely utilised in the nearby coal-fired power stations of the Trent valley. The following factors have contributed to the high yield of this group of collieries: thick seams with good roofs and lying practically flat over wide areas; a rather low incidence of major faults; the moderate depth of mining which is barely sufficient to give rise to great rock heat and unwieldy roofs; the existence of a fairly thick barrier of largely impermeable rocks between the main mining horizons and the heavily water-bearing Bunter Sandstone of the newer cover rocks; an abundant ground water supply for washery purposes; and, finally, a flat or slightly undulating surface configuration allowing for the ready erection of modern colliery buildings and ancillary plant.

## The Midland coalfields

The Midland coalfields of Leicestershire, Warwickshire, South Staffordshire and the Forest of Wyre with Coalbrookdale have certain features in common. The Coal Measures were deposited in bays or hollows in the old land mass, previously referred to as St George's Land, which then stretched across south-midland England. Frequently there are no older Carboniferous rocks than the Middle Coal Measures which therefore rest directly on the ancient floor. This ancient floor usually slopes northwards and the Coal Measures nearly always thicken from south to north. In the northern parts of the fields there are often fair numbers of coal seams which, when traced southwards, are found to converge to form one or more very thick seams. After their deposition the structure of the fields was complicated by the formation of a very extensive series of north and south faults and folds with axes of like trend. The combined faulting and folding has resulted in the further separation of the fields into distinct divisions. In addition there are frequently important east–west faults so that the geological structure of the small Midland coalfields is often very complicated.

(*a*) *Leicestershire.* This coalfield lies in a basin that is bounded on the west by the Cambrian rocks of the Nuneaton Ridge and on the east by the Pre-Cambrian rocks of Charnwood Forest. The coalfield includes an area of about 155 square kilometres (60 square miles) in the county of Leicester together with about 39 square kilometres (15 square miles) in South Derbyshire. Within this field the Coal Measures are exposed at the surface over an

area of 62 square kilometres (24 square miles) with Ashby-de-la-Zouch as a centre, the most important part of the concealed coalfield lying to the south-east. The Lower Coal Measures are thin and unimportant and only one small seam has been worked. Most of the seams lie therefore in the Middle Coal Measures which occur in the eastern and western areas, these being separated by an anticlinal fold of Lower Coal Measures. The Royster Coal on the east and the Kilburn Coal on the west are usually the lowest workable seams and are regarded as the base of the productive measures. The Main Coal is the standard coal of the district and consists of two seams in the north which unite in the south to form one thick seam of about 4.3 to 4.9 metres (14 to 16 ft). The Main Coal is a steam, house and manufacturing coal. In 1968 the seams most extensively worked were the Woodfield, Main, Eureka and Kilburn in the west and the Middle and Nether Lount in the east. The eastern section had eight productive collieries in 1968 and the western section, which extends into south Derbyshire, had four active units. Productivity levels in this coalfield are amongst the highest in the country, every colliery recording more than 2.3 metric tons (45 cwt) per manshift (overall) in 1968 with a few exceeding 4 metric tons (80 cwt) per manshift.

The Leicestershire coalfield is remarkable in one respect, that it has not given rise to an extensive industrial area and the coal mining centres have remained small towns or more often villages, as for example, Coalville. Ashby-de-la-Zouch is still essentially a country market town barely touched by coalfield development. Swadlincote, however, in south Derbyshire, is an important centre of industries based on the local resources of fireclay.

(b) *The East Warwickshire or Nuneaton coalfield.* The total area of this field is about 388 square kilometres (150 square miles), but a large part of it is occupied by the barren Upper Coal Measures to which the productive Measures form a narrow fringe on the east and north. Again the Coal Measure rocks were deposited in an old embayment. Carboniferous Limestone and Millstone Grit are nearly always absent, and the Coal Measures rest directly on the ancient Cambrian rocks. Even the Lower Coal Measures themselves seem to be absent. The Middle Coal Measures, the productive series, are about 300 metres thick in the Tamworth area in the north, but thin southwards. As one goes southwards the coal seams tend to unite so that in the vicinity of the Newdigate collieries, near Nuneaton, the separate seams have coalesced to give a thickness of over 7 metres (23 ft) to the Thick Coal or Hacksbury seam. In the northern part of the field seams with a combined thickness of 10.6 metres (35 ft) occur. In 1968 the coalfield had only six productive collieries, as compared with fifteen in 1950. Mining operations were being directed mainly at the extraction of the Ryder, Nine Feet and Two Yard seams. Productivity levels were not nearly as high as those of the Leicestershire coalfield, but Daw Hill, a new colliery sunk at a cost of over £4m midway between Nuneaton and the eastern suburbs of Birmingham, recorded the highly satisfactory yield of nearly 3 metric tons

(60 cwt) per manshift. The coals are of a bituminous nature and have been utilised for domestic and manufacturing purposes. The remaining collieries are well spaced and there are considerable areas under which the coal has remained untouched. In the southern part of the field there has been some difficulty with water in the overlying beds. The excessive thickness of the Thick Coal has also been an obstacle to successful mining. This deserves to be stressed because it might be thought that a very thick coal would be an extremely valuable one, but the expense of timbering (or, alternatively, of working the coal in horizontal sections) is enormously increased.

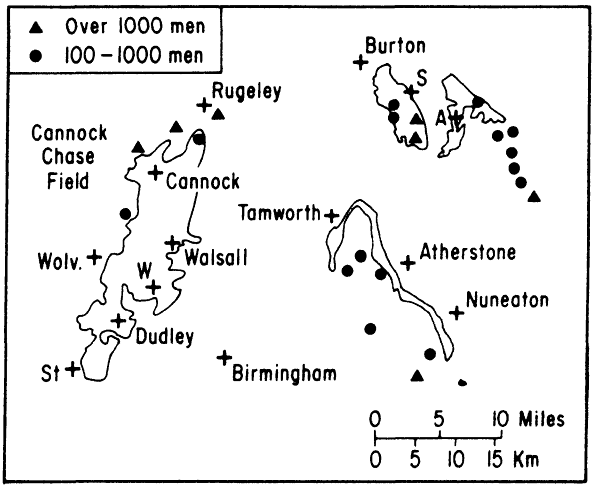



FIG. 131. The Midland coalfields, 1968
Note that mining in the old 'Black Country' is extinct

(*c*) *The South Staffordshire coalfield.* The total area of this field is about 386 square kilometres (149 square miles). Again, in the southern part, the Coal Measures rest on an irregular floor, usually composed of Silurian rocks. Structurally the field falls into three parts: in the north is the Cannock Chase basin, partly concealed beneath the Trias; this is succeeded, beyond the east–west Bentley Faults, by the northern part of the Black Country field, a shallow basin with its axis lying northwest–southeast from Wolverhampton to West Bromwich; this in turn is separated from the third area by the axial ridge of the Black Country, partly composed of a dolerite mass (the Rowley Hills) and partly of three inliers of Silurian rocks, of which Dudley Castle hill and the Wren's Nest are famous for the highly fossiliferous Wenlock Limestone that was formerly quarried and mined for use in the local blast furnaces. The southern section of the field, south of this ridge, is divided into two basins—the Pensnett and Cradley basins—by the Netherton anticline that trends northnortheast–southsouthwest. Once

again the Lower Coal Measures seem to be absent, at any rate in the southern part of the field; and even the Middle Coal Measures are only 76 metres (250 ft) thick in the south although they thicken to nearly 600 metres (2000 ft) in the north (Cannock Chase). The thinner seams in the north progressively coalesce towards the south to form the famous Thick Coal. This has an aggregate thickness of more than 9 metres (30 ft) over a considerable area and occasionally reached nearly 11 metres (36 ft). The coals

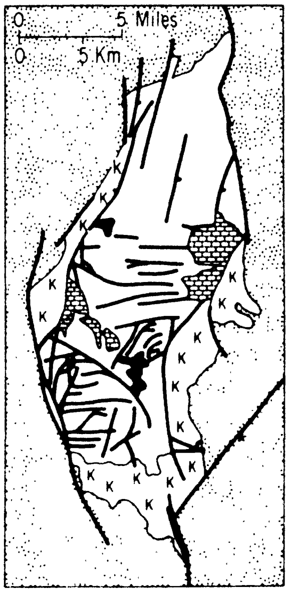



FIG. 132. Sketch map illustrating the complicated faulting in the South Staffordshire field

Silurian limestone is shown outcropping in the heart of the field; black areas are igneous rocks; K = Keele Beds (highest Carboniferous red rocks); dotted, later deposits.

of the South Staffordshire field are bituminous in character and suitable for house, manufacturing and local uses. They were formerly much prized for making the type of coke that was used for iron smelting during the Industrial Revolution—though they would not now be regarded as coking coals suitable for treatment in modern byproduct ovens. The seams of Cannock Chase have a specially high reputation as house coal. As in the two previous fields the boundary faults to the east and west are important and it is not fully known to what depths the Coal Measures may be faulted down. Several collieries have worked part of the ground beyond these faults. In 1949 the National Coal Board embarked on an extensive boring programme

designed to explore the ground east of the Rugeley Fault at the northern end of the Cannock Chase section of the coalfield. These investigations have revealed a valuable extension of the coalfield beneath the Triassic cover which was proved to have a highly irregular base. The Mealy Grey Coal, the lowest of the workable seams, was found to be succeeded by about 450 metres (1500 ft) of measures containing a dozen, or so, good seams. The Old Park and succeeding Wyrley Bottom Coals are two of the more valuable seams of this concealed coalfield. Lea Hall colliery, near Rugeley, was sunk at a capital cost of £11m to exploit these new resources and, with a 1968 output of 1.27 million metric tons (1.25 million long tons) and a productivity level of 3.5 metric tons (70 cwt) per manshift, is one of the National Coal Board's successes. In this concealed coalfield some of the upper seams incrop and are thus absent over restricted zones because of truncation at the irregular base of the Trias. This irregular plane of junction of the two formations also introduces a drainage or flooding hazard to mining operations because the Bunter Pebble Beds, in particular, are highly water-bearing.

Including Lea Hall, the Cannock Chase or northern section of the field now has only five active collieries. The southern part of the field, in the Black Country proper, is practically worked out and whereas in the mid-nineteenth century there were some 500 shallow pits, in 1968 there were no operative collieries to the south of Wolverhampton.

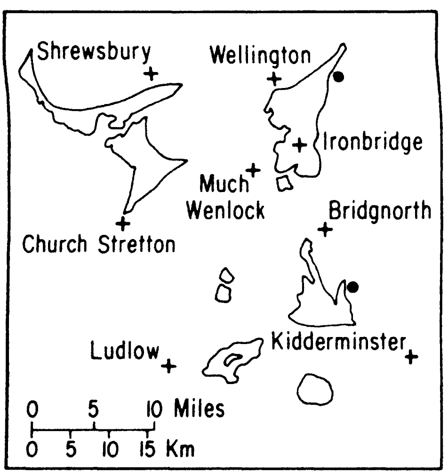



FIG. 133. The Shropshire coalfields, 1968
Only two pits remain, each with under 1000 men employed.

(*d*) *The Forest of Wyre coalfield.* This occupies a hollow in the ancient rocks, and although having an area of 130 square kilometres (50 square miles) it has very small reserves of coal. The Coal Measures here have a maximum thickness approaching 610 metres (2000 ft). The coals of the Upper Measures (Highley Group) were formerly extensively mined in shallow

pits and open workings. In the Middle Measures only the Highley–Brooch Coal was worked on a large scale. Only one colliery near Highley was operating in 1968, and that closed down at the end of the year.

(*e*) *The Coalbrookdale field.* This field has small reserves, but formerly held several productive collieries. Only one colliery was functioning in 1968; this had an annual production of rather more than 203 000 metric tons (200 000 long tons). The coalfield is of the greatest interest because of the fame of the district in the history of the iron trade. Here coke-smelted iron was first produced and at Ironbridge the first bridge constructed of iron was erected and is still standing (see Plate 16).

## The South Wales coalfield

This is different from the English fields, with the exception of its small neighbour, the Forest of Dean, in that it is a true basin of almost wholly exposed Coal Measures. Indeed, the South Wales field may be likened roughly to a pie dish elongated from east to west and with a rim which is formed of Millstone Grit and Carboniferous Limestone, usually flanked by still older rocks. The southern rim (South Crop) is generally considerably steeper than the northern rim (North Crop). In the centre of the pie dish there is a threefold sequence: the Lower Coal Series, comprised predominantly of shales with many coal seams and subsidiary sandstones; the Pennant Sandstone Series, typified by massive felspathic sandstones or grits; and, finally, the Upper Coal Series, again characterised by shales but with fewer coal seams. The three subdivisions reach their greatest thickness in the western part of the coalfield, thinning fairly consistently to the east and northeast. Although this tripartite division of the Coal Measures is often clearly reflected in the relief of the area, it has long been appreciated that it is geologically unsatisfactory, chiefly because of the markedly diachronous relationship of the Pennant to the underlying and overlying series. In its revised mapping the Institute of Geological Sciences has devised a new classification which is based on palaeontological datum planes equatable with those in other coalfields and providing for a standard form of mapping of the Coal Measures in England and Wales. This new classification is not yet in universal usage because the issue of revised maps for the coalfield is incomplete. To avoid confusion therefore the use of the old nomenclature will be retained in the following account.

One would expect the Lower Coal Series to be at their greatest depth in the centre of the pie dish. But east of Port Talbot there is a line of pronounced upfold, running eastward from west of Maesteg to the vicinity of Pontypridd, which brings many of the valuable seams of the Lower Coal Series comparatively near to the surface even in the centre of the coalfield. The Upper Coal Series are preserved in synclinal or downfaulted outliers which normally provide areas of subdued or lower relief. These include the

Gowerton–Llanelly Syncline, the Llantwit Fardre–Caerphilly and Gelligaer or Blackwood Synclines and the elongated strip of the Duffryn Trough, to the north of Swansea. The whole field has a length from east to west of about 145 kilometres (ninety miles). Its greatest width, 26 to 27 kilometres (sixteen to seventeen miles), is in Glamorgan. An average width of about

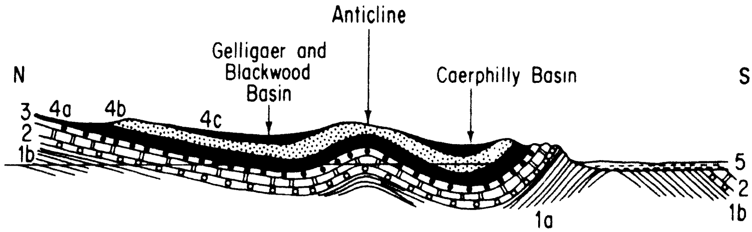



FIG. 134. Diagrammatic section through the east of the South Wales coal basin

1*a*, Silurian and lower Old Red Sandstone; 1*b*, upper Old Red Sandstone (conglomerates, etc.), 2, Carboniferous Limestone; 3, Millstone Grit; 4*a*, lower Coal Series, 4*b*, Pennant Grit, 4*c*, upper Coal Series; 5, Mesozoic and later rocks

24 kilometres (fifteen miles) is maintained as far as Swansea Bay. Westwards the coalfield narrows and in the western part of Pembrokeshire it is scarcely 5 kilometres. If one includes the portions covered by the sea in Swansea Bay and Carmarthen Bay the area of the coalfield is over 2590 square kilometres (1000 square miles) and it has very extensive reserves. The relief of the greater part of the coalfield is particularly characteristic in that deep transverse valleys have been the main factor determining the location of collieries, villages and towns. In the early days levels were opened up along these steepsided valleys and the first mines thus had natural drainage through their portals. To avoid passing through an unnecessary thickness of the Pennant Sandstone or other barren measures many pits were subsequently sunk on the floors of the valleys. Between the deeper valleys are large tracts of moorland at a considerable elevation above sea level and from the surface of these wide open moorlands it is often impossible to see a colliery and to realise that one is in the heart of a coalfield.

Turning to details of geological structure, apart from the anticlinal fold traversing the central regions of the main coal basin, there are also other smaller anticlines which to some extent bring the lower coals within mineable reach. Then the whole of the main basin is crossed by a pronounced series of faults trending in general from northnorthwest to southsoutheast or northwest to southeast, that is subparallel to the prevailing dips. Some of these are in the nature of trough faults with 'troughs' of Coal Measures let down between them, but on the whole they throw westwards so that it is in the neighbourhood of Swansea that the lower coals are found at their greatest depth. In fact, they are depressed below 1220 metres (about 4000 ft) and cannot under present conditions be mined. Belts of major faulting, completely avoided by mining operations, include the so-called Neath and

Tawe Disturbances of the upper Neath and Tawe valleys and the Moel Gilau Fault of west–central Glamorgan. Equally disturbed zones, perhaps less obvious on the surface, but with repeated low-angled faulting or thrusting have been encountered both on the South Crop and in the western half of the North Crop which forms the anthracite section of the coalfield. Large rivers, notably the Neath and the Tawe, find their way along the faulted belts towards the sea. In Pembrokeshire, folding and faulting have both been very intense; frequently the beds are overfolded and there are great thrust faults and the whole structure is such as to render virtually impossible any serious attempts at renewed mining.

The development of the South Wales coalfield has been influenced to a great degree by the high quality and the variety of the coal. While bituminous coals are present in quantity there are well-known steam coals and anthracites, both of which are characterised by a high percentage of carbon and a low percentage of volatile matter. In addition, in many South Wales coals the ash content is very small. Whilst bituminous coals commonly have an ash content of 5 to 10 per cent, that of the steam coals of South Wales is frequently under 4 per cent, and in the case of the anthracites it is only about one per cent. Anthracite is found in the detached portion of the coalfield, in Pembrokeshire, and also in the northwestern part of the main field from the Gwendraeth Valley approximately as far as the head of the Vale of Neath and the upper Avan Valley. The seams are in the Lower Coal Series. East and south of the limit of the anthracite area, as defined above, the seams change in character, each seam passing first into steam coal and then into a bituminous coal. Thus towards the South Crop of the coalfield, from the Swansea area in the west to the Caerphilly–Bedwas area in the east, the seams in the lower part of the Coal Measures are bituminous whilst between this zone and the anthracite district they are mainly steam coals of various grades. It is particularly around Aberdare and in the Rhondda Valley that the most famous of the steam coals have been mined. The coals of the Upper Series are generally bituminous coals. Broadly speaking, about 50 per cent of the coal available in South Wales is steam coal, about 30 per cent bituminous and about 20 per cent anthracite. Coal was undoubtedly worked in the South Wales field as early as the thirteenth century, while towards the end of the sixteenth century it was being used for the smelting of copper. For some considerable time much of the coal-winning on the North Crop was achieved by what is called 'patching'—digging the low-dipping, or nearly horizontal, seams in open workings. This was succeeded by workings in bell pits, the shallow pits being dug near the outcrop of the seam, and workings being made outward from it in all directions until it was considered unsafe to proceed farther.

In the latter part of the eighteenth century coal began to be used generally in the iron industry and there followed the great expansion in the export trade in iron. In due course this was followed by a similar rise in the export of coal. A detailed map of South Wales will show the way in which the

valleys in the southeast of the field join and lead to two main centres—Newport and Cardiff. The coal export trade of Newport developed particularly after the opening of the Monmouthshire Canal and the quantity exported rose from about 10 000 metric tons in 1798 to over 148 000 metric tons in 1809. Cardiff developed rapidly as the main exporting port in the middle years of the nineteenth century. Tramways and canals brought the coal to the ports and the construction of the Taff Vale railway (completed in 1841) to Merthyr and Aberdare helped greatly in accelerating the increase in the export trade. Likewise the opening of the Bute Docks at Cardiff in 1839 was a major contributory factor. In 1913 no less than 70 per cent of

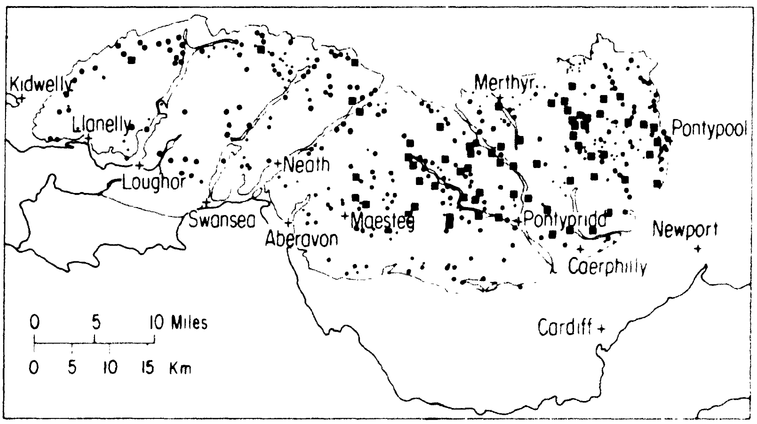



FIG. 135. The South Wales coalfield, 1931. Excluding the western extension

the total output of the coalfield was exported either abroad or to other parts of Britain by water. Cardiff, including Penarth and Barry, shipped nearly two-thirds of this, and next in order of importance were Newport, Swansea and Port Talbot. Thus the former prosperity of the South Wales coal industry depended to a very large degree on the export trade. The field suffered correspondingly in the interwar years from the diminution in that trade. In 1968 the proportion of South Wales coal exported was less than 6 per cent, and this comprised mainly anthracite from Swansea. Coke ovens now consume some 6 million metric tons out of the total of 16 million metric tons of deep-mined coal derived from the South Wales coalfield whilst electricity plants take more than 4 million metric tons.

Subsequent to nationalisation in 1947 the National Coal Board has spent more than £100m on major capital schemes in the South Wales coalfield. These embraced the reorganisation or reconstruction of existing collieries, the sinking of new pits or drifts, the reconstruction and reopening of old collieries formerly disused, and the establishment of ancillary works of a varied nature. Few of the colliery schemes have been unqualified successes.

This can be largely attributed to difficult geological conditions, particularly in the South Crop and anthracite areas, but other factors, such as the persistently high rates of absenteeism, have been partially responsible for this unhappy state of affairs. A few redeeming features are worthy of note. In the anthracite area two major new pits costing more than £10m apiece, have fallen far short of expectation in terms of yield and productivity, but three relatively shallow drift mines are between them producing 406 000 metric tons (400 000 long tons) of anthracite at productivity rates well above the average for the South Wales coalfield. Likewise quite a few of the older collieries in the central steam coal section of the coalfield have now been

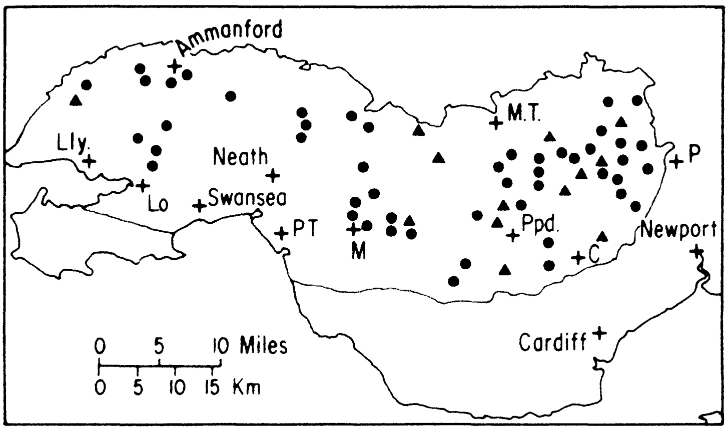



Fig. 136. The South Wales coalfield, 1968
Round symbols, 100 to 1000 men employed, triangles over 1000 men

working at a profit for a number of years. In 1950 the National Coal Board operated 163 productive mines in the South Wales coalfield. By March 1968 this number had been reduced to 62. A comparison of Figs 135 and 136 will indicate that the closures have been most in evidence in the eastern half of the anthracite district, along the South Crop and at the northern ends of the Glamorgan and Monmouthshire valleys.

## The Forest of Dean coalfield

The small Forest of Dean coalfield comprises a basin of entirely exposed Coal Measures surrounded by a rim of Carboniferous Limestone and separated from the South Wales field by a broad expanse of older rocks. The Coal Measures occupy an area of about 70 square kilometres (44 square miles) and the total thickness of the Measures is about 427 metres (1400 ft). Several coals have been extensively worked, the three main centres being the towns of Coleford, Cinderfoot and Lydney. The last operative National Coal Board colliery ceased production in 1966.

## Somerset and Gloucestershire coalfields

In Somerset and Gloucestershire there are six detached areas of Coal Measures completely different from the South Wales field in that each is surrounded by strata newer than the Coal Measures, except where a rim of Carboniferous Limestone exists (for details see Chapter 3), and most of the coal mining has been carried on under the newer formations. The exposed

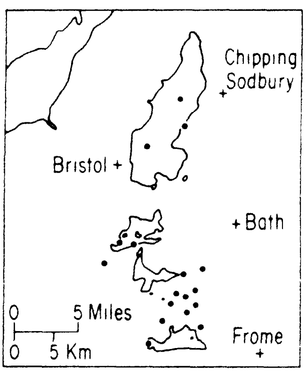



FIG. 137. The Bristol and Somerset fields, 1931

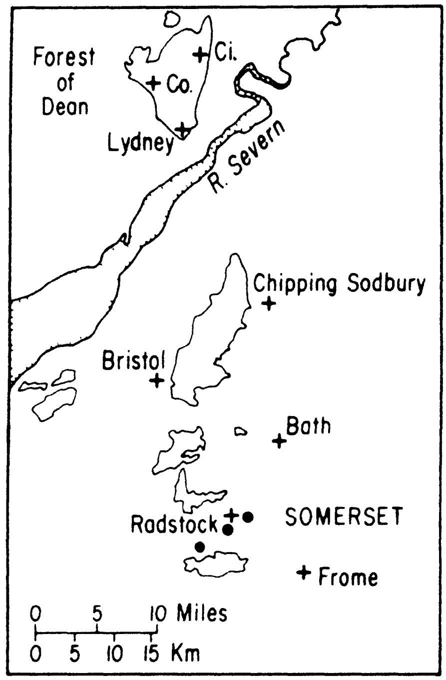



FIG. 138. The Somerset and Gloucestershire coalfields, 1968

Note that the Bristol and Forest of Dean fields are now extinct.

rocks occupy about 130 square kilometres (50 square miles) and the concealed Measures about another 492 square kilometres (190 square miles) so that some four-fifths of the total coalfield areas can actually be described as concealed. In the south there is a total thickness of about 7 metres (23 ft) of coal. Farther north in the Radstock area the seams increase in number and thickness, but the Radstock basin is traversed by several major thrusts, its southern limit being marked by a large thrustfaulted overfold. The Radstock basin had three active collieries in 1968, each showing reasonable productivity levels. In this basin three important coal seams occur in the lowest third of the Pennant Series. There are now no active collieries in the Kingswood field to the north which is poorer in coals.

Geologically these coalfields in Somerset and Gloucestershire are in-

teresting in that some of the coals are believed to be of much younger date in the Coal Measures sequence than those in other parts of England.

## The East Kent coalfield

Long before the end of last century geologists confidently predicted that a concealed coalfield would be found underneath southeastern England. Prestwich and Godwin Austen, in particular, in the seventies of last century were certain of the matter. The field was first discovered when excavations

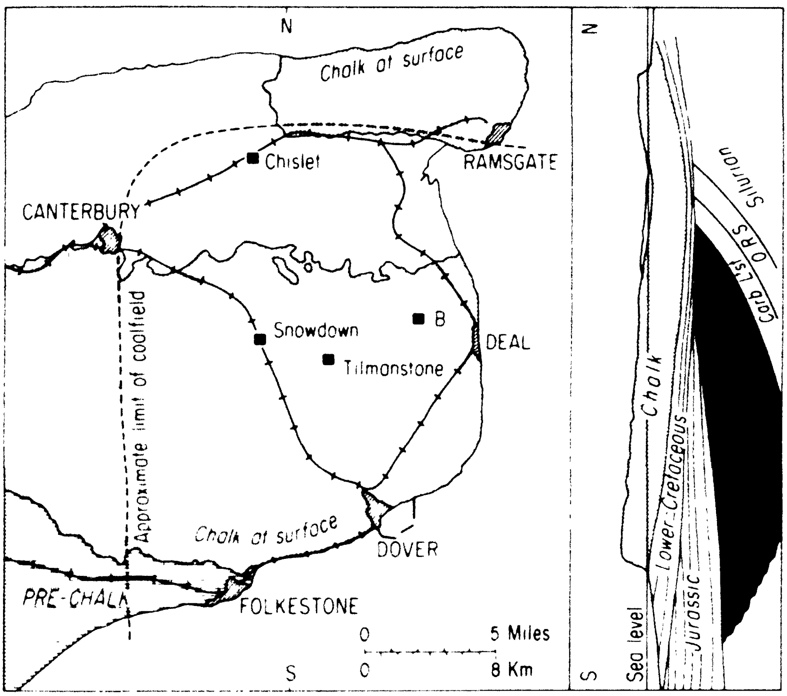



FIG. 139. The East Kent coalfield and a section through it (with the Coal Measures in black)

The area with a stippled margin is where chalk outcrops at the surface. The four collieries are those working in 1961 B = Betteshanger

for the proposed Channel tunnel near Shakespeare Cliffs, Dover, were temporarily suspended and engineers bored downwards. This occurred in 1890. During the succeeding twenty-five years a number of boreholes were put down and the limits of the coalfield were broadly determined. It forms a basin extending as far north as Sandwich, a little north of Canterbury, and westwards is bounded by a sharp upfold so that there is a rough north–south line limiting the field a short distance west of the longitude of Folkestone. It is now estimated to have an area of 534 square kilometres (206 square miles), of which 145 square kilometres (56 square miles), however, lie at a

workable distance from the shore but below the sea. The Coal Measures trough is now thought to be deepest around Waldershore and St Margarets Bay where it reaches to about 1460 metres (3800 ft) below O.D. and the Coal Measures attain a maximum thickness of some 884 metres (2900 ft). On land the top of the Coal Measures lies at depths of 305 to 488 metres (1000 to 1600 ft). Fourteen more or less persistent coal seams have been recognised; some of these are more than 1.5 metres (5 ft) thick, but many are split. Much of the coal has strong caking properties, but in view of its rather friable nature the proportion of fines is rather high.

The four active mines of the coalfield are of comparatively long standing and so have extensive takes, as much as five miles across. A notable proportion of the annual production of 1.5 million metric tons is consumed in the cement, gas and electricity industries. The field is conveniently situated for the port of Dover, and an overhead ropeway was installed to take coal in limited quantities to that port.

## The Scottish coalfields

The Scottish coalfields differ very much in character from those of the rest of Britain in that important coal seams occur not only in rocks of Coal Measure age but also in rocks which are contemporaneous with the great mass of the Carboniferous Limestone as developed in England and Wales. Most of the Carboniferous Limestone coals are in the middle subdivision of that series which is known as the Limestone Coal Group. Geologically, of course, the whole Midland Valley of Scotland is a broad syncline of sedi-

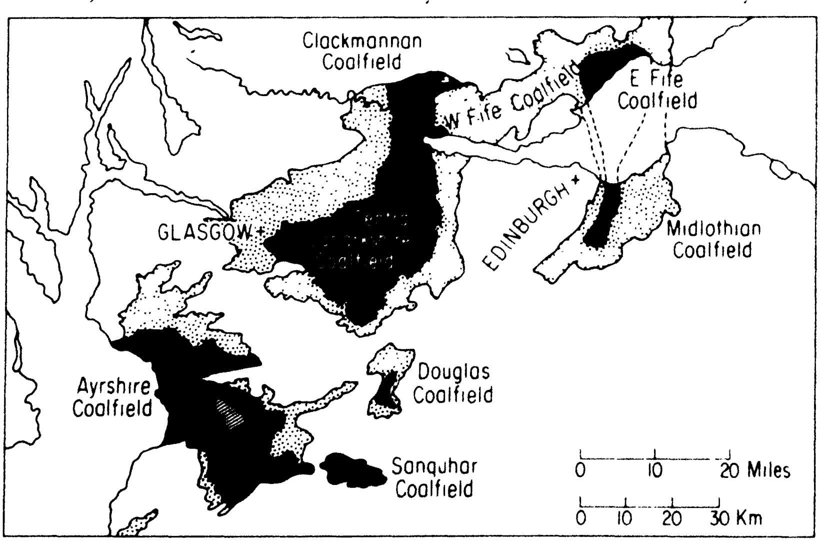



FIG. 140. The Scottish coalfields

The Coal Measure fields are shown in solid black: the Carboniferous Limestone fields are dotted. All the fields are basins, wholly exposed except where the eastern field is covered by the waters of the Firth of Forth and where a patch of Permian occurs in the heart of the Ayrshire field

mentary rocks let down between the older rocks of the Highlands on the north and of the Southern Uplands on the south. Broadly speaking, the youngest rocks are near the centre of the syncline, the older rocks along its margins. Consequently there is a broad belt of Old Red Sandstone along the northern margin and a narrower, less continuous belt along the south. Carboniferous rocks occupy much of the centre, but it is clear that folding and denudation had gone on before the formation of the Coal Measures and, at least in some cases, the Coal Measures occupy basins filling up old hollows in the pre-existing floor. Most of the ten more or less well defined basins occupied by Coal Measures are, however, folds within Carboniferous rocks which have been formed by subsequent earth movements. The extent of the fields is roughly shown in the accompanying diagram and broadly speaking it can be seen that there are three important areas:

The Ayrshire coalfield.
The Central coalfield, lying largely in Lanarkshire but with extensions northwards into Stirling and Clackmannan.
The Midlothian–Fifeshire coalfield, where actually the Coal Measures as well as the Carboniferous Limestone are continuous under the Firth of Forth which, however, divides this area into two fields, the Fifeshire field to the north and the Midlothian field to the south.

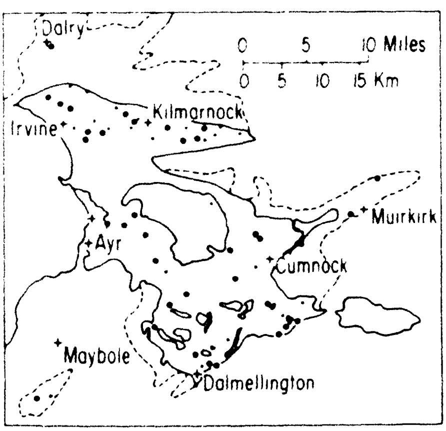



FIG. 141. The Avrshire fields, 1931, distinguishing the Coal Measure fields from the here unimportant Carboniferous Limestone fields. One important colliery should have been shown in the Sanquhar basin

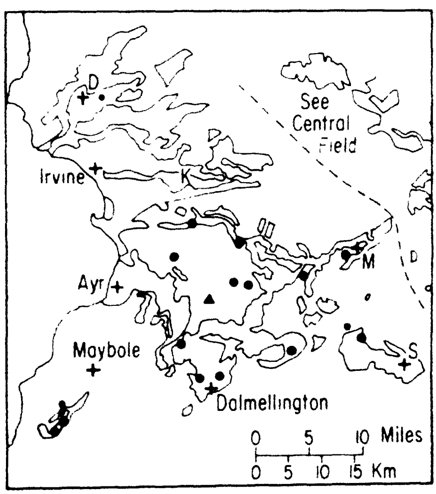



FIG. 142. The Ayrshire coalfields, 1968
Small dots, under 100 men employed, large dots, 100 to 1000, triangles, over 1000

Few of the Scottish coal seams have a wide lateral extent. This is particularly the case with the Limestone Coal Group. Further, individual seams tend to vary greatly in thickness, often within short distances. Some of the

best coals average under three feet in thickness, but locally the seams may swell out to over 6 metres (20 ft). Most of the Scottish coals are bituminous coals, though first-class steam coals are present and there are good bunker coals. There are, in addition, a number of high-quality gas and coking coals.

(*a*) *The Ayrshire coalfield.* Over much of the Ayrshire coalfield the Coal Measures are disposed in a number of synclines with the intervening anticlines often broken by faulting. These structures generally have a northeasterly trend. The Productive Coal Measures have a maximum thickness of about 458 metres (1500 ft), but are succeeded in places by an upper group, the Barren Red Measures. Complex belts of close faulting are locally a feature. The coals are mainly bituminous and are chiefly used for steam raising and domestic purposes. In a few instances seams affected by intrusive sills of teschenite have been rendered anthracitic.

In recent years closures of uneconomic collieries, or those at which the main reserves have been exhausted, bear no comparison with the degree of cessation of mining activity apparent in the Central coalfield. The majority of the Ayrshire collieries still active recorded productivity rates at or above the Scottish average in 1968. The new Killoch colliery, near Ochiltree to the east of Ayr, established with a capital outlay of more than £9m, is now the largest productive unit in the area with an annual output of over one million metric tons, a labour force of 2000 and a productivity rate of more than 2 metric tons (40 cwt) per manshift which in Scottish terms is highly satisfactory.

(*b*) *The Central coalfield.* Coal mining in the Central field of Scotland has long been associated with the iron and steel industry of such centres as Airdrie, Coatbridge, Motherwell and Wishaw. The greater portion of the field lies in Lanarkshire, but to the east and southeast it extends into West Lothian, Stirlingshire, Dunbartonshire and Clackmannanshire. The small outlying Douglas coalfield, which had four active collieries in 1968, lies in south Lanarkshire. Excluding this minor field but including its eastern and northeastern extensions the Central field contained only twelve productive collieries. The scale of colliery closures since 1960 bears comparison with parts of the South Wales coalfield. Disused shafts and drifts are now a feature of the landscape, particularly in the Coatbridge–Hamilton area and again to the east and southeast of Airdrie. Many of the closures can be related to difficult structural conditions or to the exhaustion of the more accessible seams. Quite a few were drifts with limited mining complements. A few new drift mines opened up as major capital projects by the National Coal Board have recorded encouraging yields; on the other hand some reconstruction schemes have proved disappointing mainly because geological conditions have turned out to be more complex and disturbed than was indicated by exploratory boring or surface conditions. A case in point is the Glenochil

drift mine near Alloa which was closed in 1961 after expenditure of more than £5m on its development. The ancient ports of Bo'ness and Grangemouth have long served the Stirlingshire and Clackmannanshire extensions to the field by shipping coal and importing pit props. Clackmannan is still largely an agricultural county and the mine workings are not unduly obtrusive.

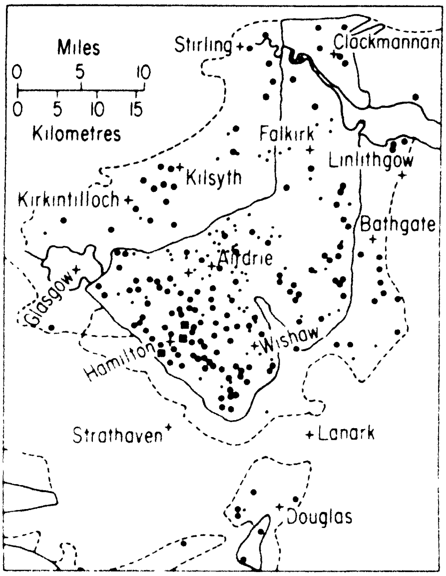



FIG. 143. The central coalfield, 1931

This map shows by a solid line the boundary of the upper Coal Measure coal-bearing series and by a pecked line the boundary of the Carboniferous as a whole. FIG. 144 shows more exactly the outcrops of the two coal-bearing series

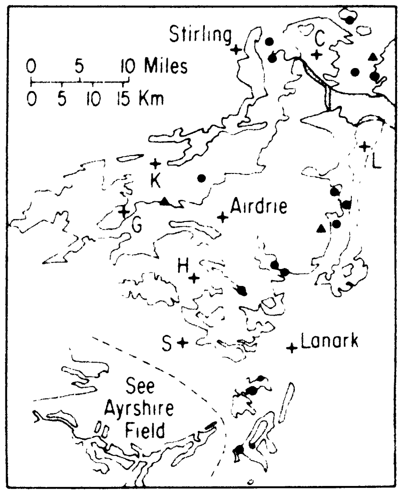



FIG. 144. The central coalfield, 1968

Small dots, under 100 men employed, large dots, 100 to 1000, triangles, over 1000. The reduction in the number of pits since 1931 is remarkable, as is also the small number of large pits

(c) *The Fifeshire coalfield.* This field contains large reserves of coal despite a long history of past mining. These reserves nevertheless are becoming increasingly more difficult and costly to reach. In the eastern half of the field they lie principally in the Productive Coal Measures beneath the waters of the Firth of Forth and at substantial depths in the Limestone Coal Group both on land and in the undersea extension. A deep shaft was sunk by the National Coal Board near Thornton (Rothes colliery), at a capital cost of more than £10m, to tap these reserves in the Limestone Coal Group. This was finally abandoned in 1962 when it was disclosed that exceptional underground conditions had severely affected results. Eight kilometres south on the coastline to the south of Kirkcaldy the new Seafield colliery, costing £15m, has in the past few years started extracting seams of the Limestone Coal Group from beneath the Firth of Forth. Between 1955 and 1957 an offshore boring tower completed six boreholes to an average depth of 915 metres (3000 ft) in the Firth and these verified the former speculation con-

cerning the seaward extension of the coalfield towards the east and south. It is now wellnigh certain that the Coal Measures of East Fifeshire are continuous with those of the Midlothian Basin on the opposite side of the Forth. It seems likely that future undersea workings will be at substantial depths. In the centre of the Firth it has been postulated that there is a deep pre-Glacial channel filled with unconsolidated materials extending to depths reaching beyond 150 metres (500 ft) below O.D.

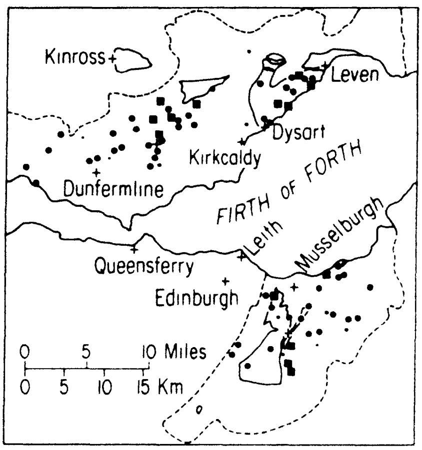



Fig. 145. The eastern coalfields of Scotland, 1931

The importance of the lower group (Carboniferous Limestone group) in Fifeshire is very apparent

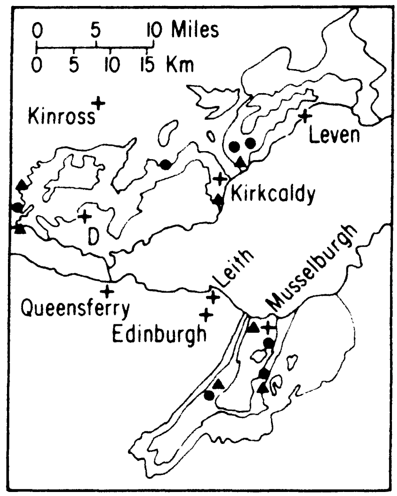



Fig. 146. The eastern coalfields of Scotland, 1968

Symbols as on Fig 144

On land the major structure affecting the Coal Measures is the Burntisland Anticline whose axis extends in a northnortheasterly direction from near Burntisland to the vicinity of Markinch. On the eastern flanks of this large upfold the rocks have been flexed into a series of lesser folds trending roughly from north to south and disturbed by a number of east–west faults. The Productive Coal Measures reach their maximum thickness of some 518 metres (1700 ft) between Methil and Kirkcaldy where they contain up to twenty workable seams. West of Kirkcaldy and in the West Fife Coalfield, in general, practically all the workable seams are found in the Limestone Coal Group. This reaches a maximum thickness of 427 metres (1400 ft) in the deepest part of the Lochore syncline where the total thickness of the component seams may reach nearly 30 metres (100 ft). In places the coals have been destroyed or otherwise affected by igneous intrusions. Near Cowdenbeath and Dunfermline there are numerous east–west faults so that the coal-bearing strata are now preserved in a series of small basins bounded to the north and south by dislocations.

## The Midlothian and East Lothian coalfields

The Midlothian coalfield is structurally an asymmetrical syncline with a steep western limb, the axis of which runs in a general northeasterly direction to the sea near Musselburgh. The great Pentland fault of similar trend forms its western boundary whilst to the east it is separated from the East Lothian coal basin by the D'Arcy-Cousland anticline. Workable seams are found both in the Limestone Coal Group and in the Middle and Lower subdivisions of the Coal Measures. The Limestone Coal Group averages 244 metres (800 ft) in thickness and contains up to fifteen seams of commercial significance whilst the Productive Coal Measures (i.e. the Middle and Lower subdivisions) are normally about 400 metres (1300 ft) thick and show thirteen workable coals. The Limestone Coal Group thins generally

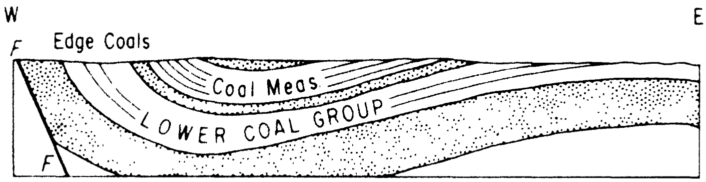



FIG. 147. A section across the Midlothian coalfield

to the south and southeast and as a result is less than 91 metres (300 ft) thick in the extreme south of the basin. From the southern coastline of the Firth of Forth near Musselburgh workings within the Limestone Coal Group have been extended northward for more than 3 kilometres in the undersea extension of the coalfield. Two major new collieries (Monkton Hall and Bilston Glen), whose shafts were sunk near Newcraighall and to the southwest of Dalkeith, respectively, were designed to win coal from the Limestone Coal Group in the deeper, flatter and as yet largely untapped central portions of the basin. In 1968 both were producing coal at the rate of 914 000 metric tons (900 000 long tons) per annum and with highly satisfactory productivity levels. Recent colliery closures have resulted in a cessation of mining in the East Lothian basin and in the southern half of the Midlothian basin. An annual production of over 3 million metric tons is now being achieved from six collieries all lying within 9.5 kilometres (6 miles) of the outer southern or eastern suburbs of the city of Edinburgh. In conclusion one might note the apt name given to the seams of the Limestone Coal Group—Edge Coals—on the steeply upturned western edge of the Midlothian basin.

## Northern Ireland

The exposed coalfield of East Tyrone lies to the immediate west of Lough Neagh and is of limited extent. The beds occur within a structural continuation of the Midland Valley of Scotland and workable coals occur in rocks

of both Carboniferous Limestone and Coal Measure age. The only other known coalfield lies to the east of Ballycastle. It occupies a hollow in the old highland rocks and coal seams are again present in strata of Carboniferous Limestone age. Small quantities of coal have been produced from both coalfields, but the quality is rather poor.

## The Irish Republic

Although a geological map shows several areas of Coal Measures the coal seams in them are unimportant and practically all the coal required by the Irish Republic has to be imported.

### PEAT

The Tertiary paleogeography of the British Isles did not lend itself to the formation of great thicknesses of *lignite* such as those of parts of the North European Plain. Only in one tiny area—the Oligocene basin of Bovey Tracey in Devonshire—are seams of lignite known to occur. They were quarried and even mined during the Second World War—though more, it must be admitted, as a source of montan wax than as fuel—and they are unlikely to be worked again.

The peat resources of the country have been estimated at 10 000 million metric tons. This is equivalent to no more than twenty to twenty-five years' consumption of coal at present rates. A considerable volume of peat has been extracted in the past from such lowland bogs as those of Fenland, the Norfolk Broads area and the Somerset Levels, and from isolated bogs at higher levels such as Macclesfield Moss. Little use has ever been made of the upland peat bogs of the Pennines or the Scottish Highlands, though many a Scottish croft has made use of its local resources. Undoubtedly the greatest potentiality lies in central Ireland (see Fig. 75), and here a considerable industry has developed, with milling and briquetting and the use of the fuel in several electric power stations.

Although some 600 000 hectares (1.5 million acres) of peat have probably been cut since 1800, there remain a further 1.2 million hectares (3 million acres), the bulk of which is in the Irish Republic. The modern large-scale utilisation of this resource postdates the Second World War, and an organisation called Bord na Móna has been responsible for much of the development. There are about 40 500 hectares (100 000 acres) of peat bog in patches larger than 400 hectares (1000 acres), and a further 120 000 hectares (300 000 acres) in smaller but still economically workable areas. Mechanical excavators dig the peat, and lorries and light railways carry it to the milling and briquetting plants and to the power stations. Long-distance transport is out of the question since six times the volume of peat is

required compared with coal to yield a given quantity of heat energy. Seven power stations now depend on milled and sod peat for their fuel supply (see Fig. 156). The first was at Portarlington, and the largest is at Ferbane, near Athlone. In addition, considerable quantities of processed peat are used as industrial and domestic fuel.

## MINERAL OIL AND GAS

The serious search for oilfields in this country began during the First World War under the auspices of the Geological Survey at a time when the German submarine menace made home supplies of all commodities of vital importance. Prior to this, one occurrence of natural gas had long been known. About the middle of the last century a well near the new railway line at Heathfield in Sussex tapped a small gas field and natural gas was used to light the lamps at Heathfield station for some years. Exploration during the war was concentrated on the Carboniferous rocks of the Midlands of England where traces of bitumen had long been known, and in central Scotland in the area where oilshale had long been worked. Some small shows of oil were detected, but the net result was a solitary oil well, at Hardstoft in Derbyshire.

In the period between the wars the Government passed the Petroleum Production Act in 1934, an Act which nationalised the oil resources of the country, at that time unknown except for the Hardstoft occurrence. This first decree of nationalisation by the Government received remarkably little attention, but it permitted the Crown to encourage active exploration for oil, which was undertaken by a subsidiary of the Anglo-Iranian Oil Company.

Many trial borings were made in the south of England and in the Midlands and north, greatly adding to our knowledge of the geological structure,[1] but only in one area has much success followed these efforts. In the East Midlands a number of anticlinal structures in the concealed Carboniferous rocks have yielded oil in commercial quantities since 1939. The first areas to be developed were at Eakring, Kelham and Caunton (near Newark) in Nottinghamshire; their output, which reached a peak in 1943, was sent by rail to Pumpherston in Scotland for refining (see below, p. 330). Later discoveries at Plungar in the Vale of Belvoir, at Egmanton near Tuxford, and in several localities near Gainsborough, brought the East Midlands output to 86 400 metric tons (85 000 long tons) in 1960.

By the end of 1960 the oilfields of Britain had yielded a total approaching a million and a half metric tons of oil. Such figures seem large until they are measured against imports and consumption. In 1960 home production was about 0.3 per cent of consumption.

1. N. L. Falcon and P. E. Kent, *Geological Results of Petroleum Exploration in Britain 1945–1957*. Geol. Soc. Memoir no. 2, 1960.

## Oil shale

Oil shale, unlike coal, was worthless until industrial technique had reached a high degree of development. Oil shales were known to occur in the Carboniferous rocks of Scotland and although they had never been worked for any purpose some of them were so rich in oil that they could easily be kindled into flame, and it was in the 1850s that James Young, using a seam near Broxburn, produced oil on a commercial scale. He was so successful that Scotland began to supply almost all the worldwide demand for mineral lubricant and lighting oils, as well as for paraffin wax. It was not until 1859 that petroleum was discovered in commercial quantities in Pennsylvania and American competition appeared. The richer shales of Scotland yielded as much as 364 litres (80 gallons) of oil per ton. When these were exhausted yields from poorer shales dropped to about 91 litres (20 gallons) per ton, but the byproducts proved more valuable than both the oil and wax obtained. In particular large quantities of ammonia were obtained which combined with sulphuric acid made on the spot to form ammonium sulphate, a valuable fertiliser. For the greater part of a century the production of shale oil from Scotland went on, and the countryside of West Lothian is littered with gaunt red spoil heaps of burnt shale. The output of crude oil in the 1930s was about 127 000 metric tons (125 000 long tons) a year. Wartime needs during the Second World War stimulated production, which reached 151 000 metric tons (149 000 long tons) in 1941. The shale was refined at Pumpherston. Production fell to 61 000 metric tons (60 000 long tons) of oil in 1960 and ceased in 1964.

## Natural gas[1]

Apart from the isolated occurrence of natural gas at Heathfield, mentioned above, the first discovery of real importance was made in the 1950s in north-east Yorkshire, where a deep boring in Eskdale not only discovered potash salts resembling those of the famous Stassfurt deposits of Germany but also struck methane gas in the Magnesian Limestone. Some of this gas was later piped to Whitby, and in the early 1960s several more successful bores were put down in the same area. These discoveries, together with the development of the great gas fields in the Netherlands, naturally led to the speculation that anticlinal structures beneath the North Sea might yield gas and perhaps oil as well. Towards the end of 1964 intensive undersea drilling began, and during the next four years over one hundred wells were drilled, mostly into the gasbearing horizons in the Permian, or sometimes into the Lower Trias. The first commercial strike was made in September 1965 in the West Sole field, some 65 kilometres east of Holderness (Fig. 148), at a depth of nearly 3000 metres, and a pipeline was subsequently laid beneath

1. T. M. Thomas, 'The North Sea gas bonanza', *Tijds. v Econ. en Soc. Geog.*, 1968, 57–70.

the sea floor to Easington on the Yorkshire coast. The Leman Bank and Hewett fields were proved in 1966, the latter only 25 kilometres from the Norfolk coast, and a number of other successful strikes followed, a pipeline being laid in 1967 to Bacton. Little oil has so far been tapped. The piping of the gas inland to join the existing natural-gas pipeline from the Canvey terminal to Leeds is referred to below (p. 336).

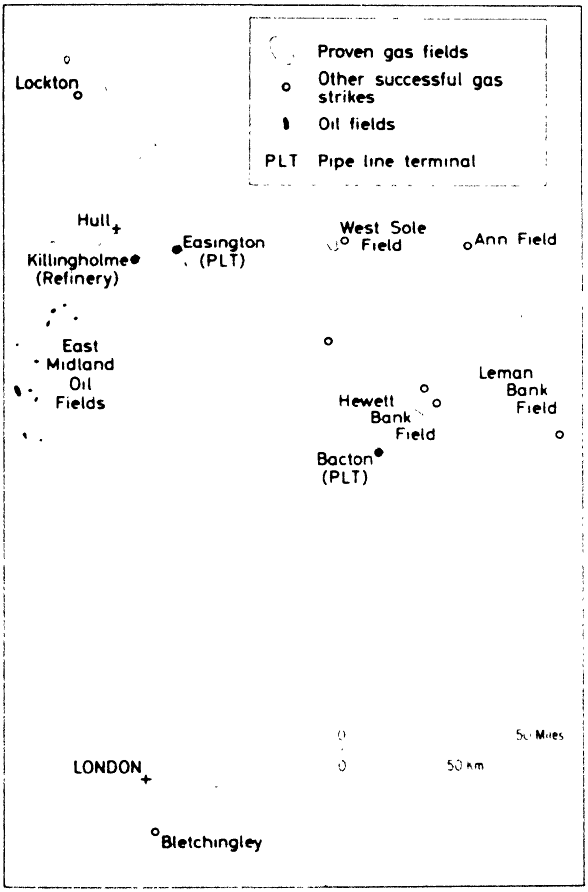



FIG. 148. The oil and natural gas fields of England and the North Sea

## FUEL AND ENERGY PRODUCTION AND USE

The total quantity of fuel and energy (including water power) used in the United Kingdom about 1950 was equivalent to 226.5 million metric tons (223 million long tons) of coal. Coal, about 203 million metric tons (200 million long tons), represented about 90 per cent of the whole, and about 10 per cent was derived from imported oil. Water power and all other

sources supplied only 0.5 per cent. Since that time coal output has dropped to 162.5 million metric tons (160 million long tons) and oil imports have risen to 76.2 million metric tons (75 million metric tons), whilst electricity derived from nuclear energy has entered the picture, as also has natural gas, and there has been a small but significant increase in the hydroelectricity output in Scotland.

## The changing use of coal

In 1913 when British coal production reached its peak of 291.6 million metric tons (287 million long tons) the country was producing more than one-fifth of all the coal mined in the world. During the interwar years, with a world output approximating to 1524 million metric tons (1500 million long tons) a year, the United States was mining roughly one-third, Great Britain one-sixth and Germany rather less than a sixth. In 1913 almost exactly one-third of the total coal mined was sent out of the country as export and bunker coal; an all-time maximum export of 99.2 million metric tons (97.6 million long tons), or over 35 per cent of the output, was reached in the boom year of 1923. During the Second World War the total of export and bunker coal fell to less than 3 per cent of the coal mined, but in the years following the war recovered temporarily to nearly 10 per cent in 1949, only to fall to less than 3 per cent by 1961, and to 1.3 per cent by 1968.

With an increasing population one would expect a fairly steady or slight upward trend in the total home demand for coal. But this came to an end in 1956 in face of competition from cheap imported oil. Considering only the coal retained for home consumption the following table shows, in percentage form, the changes in use to which it was put.

| USER | 1923 | 1938 | 1955 | 1961 | 1969 |
|---|---|---|---|---|---|
| Collieries | 9.6 | 6.9 | 4.0 | 2.5 | 1.2 |
| Railways | 7.9 | 7.5 | 6.0 | 4.6 | 0.1 |
| Coastwise bunkers | 0.8 | 0.7 | 0.3 | 0.1 | * |
| Gas works | 9.9 | 10.9 | 13.2 | 12.3 | 4.3 |
| Coke ovens | 11.2 | 10.9 | 12.7 | 14.9 | 15.5 |
| Electricity works | 4.1 | 6.4 | 20.1 | 30.6 | 47.1 |
| Miners coal | 3.7 | 2.6 | 2.4 | 2.6 | 1.8 |
| Domestic } Industrial } | 52.8 | 26.1 | 15.2 | 15.8 | 11.5 |
| | | 26.0 | 26.1 | 16.6 | 13.3 |
| Miscellaneous | — | — | — | — | 5.2 |

* Included in 'miscellaneous'.

For more recent years the table shows a steady decrease in the coal consumed by gas works and an enormous increase in that used by electricity works. The decline in consumption by the gas industry has accelerated rapidly in recent years with the introduction of North Sea gas; whilst con-

sumption by power stations continues to rise despite the use of oil fuel and atomic energy. The railways ceased to be a significant user of coal after 1966 because of the general replacement of steam engines by diesels or electric traction. The big drop from 1938 to 1955 in domestic consumption was due to rationing. The year 1955 was one of acute shortage and a large import. Many industries were forced to consider the possibilities of utilising other forms of fuel, particularly oil, and thus by 1957–58 there was a complete change around in the fortunes of the coal mining industry—the main problem then became, and this persists to the present day, one of over-production and monthly surpluses. The domestic market has likewise witnessed a steady decline and this is primarily due to wider installation of central heating appliances based on oil, electricity and, in the more recent period, natural gas.

## Coke

Domestic coke is a byproduct of the gas industry and as such was produced by almost every coal-burning gas works up and down the country. Metallurgical coke, however, is produced by coke-oven plants for use in iron and steel works, and the industry has an interesting geographical pattern which may be briefly analysed.[1]

Coke for iron smelting was probably first made by Abraham Darby at Coalbrookdale in the early part of the eighteenth century. He used lump coal of relatively low rank (78–79 per cent carbon) and almost free from sulphur, and carbonised it in open heaps. This method, with similar coals, became standard practice in the Black Country and elsewhere during and after the Industrial Revolution. Then, towards the middle of the nineteenth century the 'beehive' oven was developed to use the 'smalls', or 'slack', of strongly-swelling, 'caking' coals of higher rank (carbon 85 per cent or more). Progress in this case was most rapid in the Durham coalfield, particularly rich in such coals and lying in such close proximity to the rapidly growing iron town of Middlesbrough; but the coking coals of Yorkshire and Derbyshire were also coked in beehive ovens. For various reasons the development of the byproduct recovery oven was slow in Britain compared with the continent. There was an abundance, in certain areas, of coking coals of superlative quality, but the relative stagnation of the iron and steel industry during the last quarter of the nineteenth century did not encourage high capital outlay on new coking plant. In 1900, 80 per cent of British coke was still produced from beehive ovens and only 8 per cent from byproduct ovens. But by 1914 the beehive percentage had dropped to 31 and the byproduct figure had risen to 62, and after the First World War the beehive oven rapidly became almost extinct. Byproduct ovens, using

1. S. H. Beaver, 'Coke manufacture in Great Britain: a study in industrial geography', *Trans. Inst. Br. Geogr.*, 17, 1951, 131–48.

crushed or slack coal of similar quality to that used for beehives, yield considerable quantities of tar, benzole, benzine, naphtha, ammonia and many other products which make coke production a chemical industry of some significance. Nevertheless the main function of the coke oven is still to produce coke for iron smelting.

The modern coke industry is located in two types of situation—at or near the collieries which produce coal of suitable quality and alongside iron and steel works. Only a few of our coalfields and coal seams yield coal of suitable quality—though with the development of scientific blending the range is increasing—and in consequence the coalfield coke industry is located in three main areas only, in south Durham, in south Yorkshire and northeast Derbyshire, and in eastern South Wales. In addition to these pit-head cokeries, however, vast quantities of coke are now made at 'integrated' iron and steelworks (see below, p. 397) both on the coalfields—as at Rotherham, Glasgow and Ebbw Vale—and away from the coalfields—as at Middlesbrough, Scunthorpe, Corby and Newport—for coke is more expensive to transport than coal and the 'waste' gases from the ovens can be used in the works for various power-producing purposes as well as for their by-products. In those areas where coke is made the gas is frequently used to supplement the local gasworks' output for domestic and industrial use. The Sheffield area actually has a 'gas-grid' on the same general principle as the electricity 'grid'.

The total production of oven coke in 1969 was 16.5 million metric tons from 25.0 million metric tons of coal. The South Wales coalfield provided 4.6 million metric tons, the Yorkshire coalfield 4 million metric tons and the Durham coalfield 3.3 million metric tons. Nearly 10.6 million metric tons were disposed of in blast furnaces, the demand from this quarter having diminished by 1 million metric tons, or thereabouts, since 1960. With technological improvements in blast furnaces and iron foundries, less coke is required per ton of metal and the demand for metallurgical coke has been falling on this account. With the installation of smokeless zones in towns there have been local increases in the demand for coke and other manufactured fuels, both in industry and in domestic usage.

## Gas

The use of coal to produce gas began in 1805, when Murdock lighted a mill in Manchester with gas; two years later a German, Winzau, who had failed to arouse enthusiasm for his schemes in his own country, raised enough capital in London to carry out the lighting of Pall Mall, the first public thoroughfare in the world to be illuminated by gas. His company received a royal charter in 1812 and later became the Gas, Light and Coke Company. Steady progress in the manufacture and use of gas for town lighting and domestic purposes was made during the nineteenth century. Up to 1890, however, the lighting properties of the gas depended on those vapours it

contained which burnt with a luminous flame; later it was discovered that it was better and cheaper to remove from the coal gas these luminous gases and to rely on the heating properties of the gas to raise metallic oxides on gas mantles to so high a temperature that they became incandescent. So the problem became to maintain the heating properties of the gas at a maximum and to recover from the gas the vapours which had previously given luminosity to the flame. Gas is produced by heating bituminous coal in closed vessels called retorts. The volatile gas is removed and the porous coke, which remains, contains as high a proportion of carbon as anthracite and is used for similar purposes, especially for central heating.

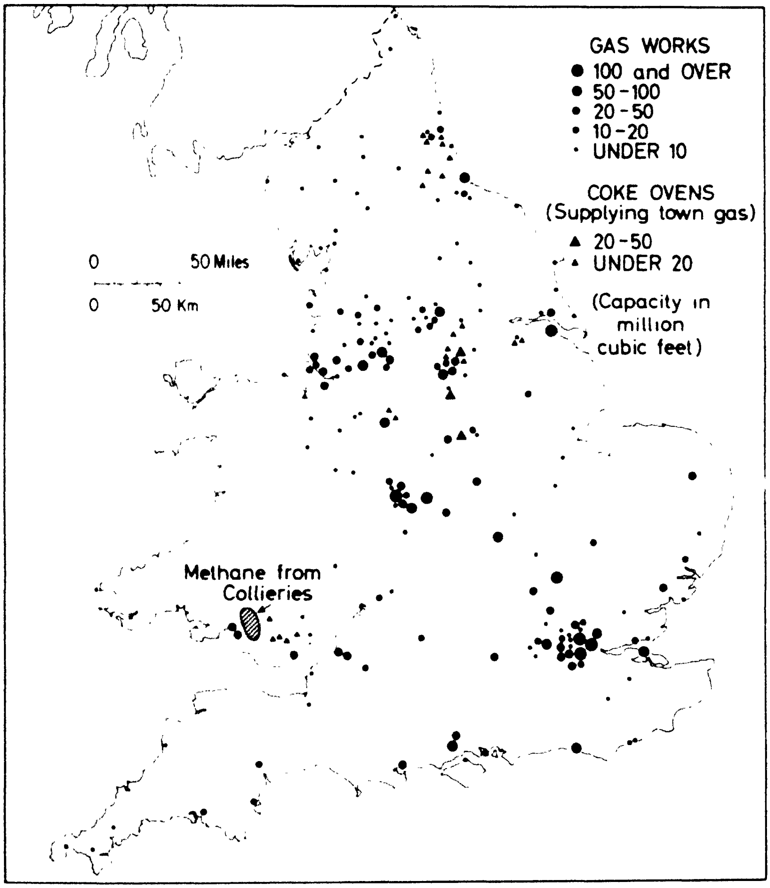



Fig. 149. The gas industry, 1967

On nationalisation in 1949 there were 1050 gasworks in production, the above map shows that in 1967 there were less than 300, but the total capacity had risen by over 25 per cent. In 1971 the total had been reduced to about 100, of which only 3 made gas from coal.

Formerly, gas was produced almost entirely within the main centres of consumption, so that every town had its gasworks, the main siting factors of which were proximity to a railway or navigable waterway, for coal

supplies. Before the Second World War a few gas-grids existed in the major conurbations, but they were of limited extent and quite unconnected with each other (see Ordnance Survey 1:625 000 map, *Gas and Coke*, 1952—relating to the 1949 position). Since the industry was nationalised in 1949 it has been organised on a regional basis; smaller and less efficient works have been closed, and from being an essentially market-orientated industry it has become concentrated at the larger markets, at the location of its raw materials, and at tidewater sites, whilst an extensive mileage of pipelines has been laid down for regional distribution. To an increasing extent also the regional Gas Boards have purchased bulk supplies of gas from the coke-oven plants of the National Coal Board and the integrated iron and steel works, and in a few localities methane gas pumped from coal mines has contributed to the supply.

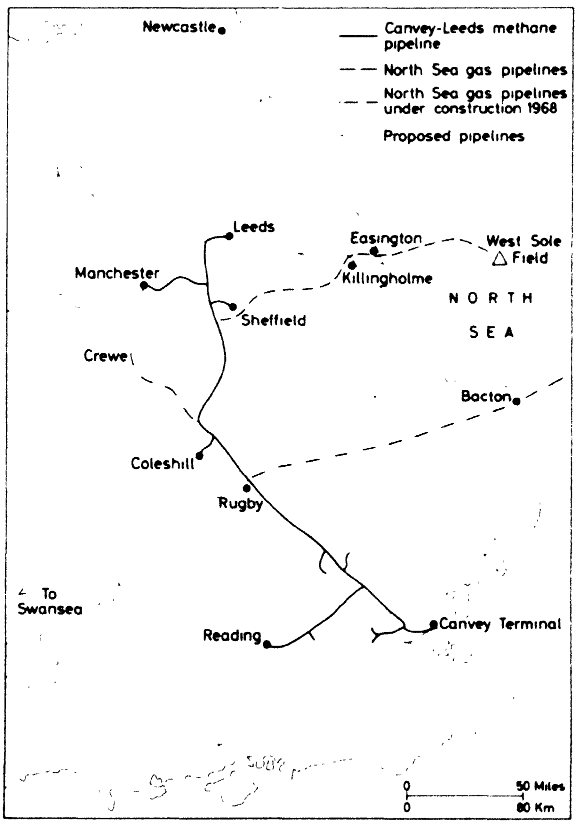



FIG. 150. Natural gas pipelines, 1968

Technological progress has been extremely rapid since 1950, and amongst the most important developments has been the making of gas from oil—either by catalytic gasification at ordinary gasworks or at new, specially

built works, or in the normal course of oil refining ('tail gases' which are subsequently modified to the required calorific value). Another development was the gasification of low grade coal by the German 'Lurgi' process; a plant at Westfield in Fifeshire has used opencast coal since 1961, but an even newer works at Coleshill, near Birmingham, has already been closed as out-of-date, so rapid has been the efficient development of oil and of natural gas.

Natural gas, referred to above (p. 330) has been imported in specially constructed tankers from North Africa since 1963, and a pipeline was constructed from the Canvey Island terminal on the Thames estuary to Leeds (Fig. 150). The development of North Sea gas and its piping to the major industrial areas has added an entirely new economic factor in the gas industry, and the precise part to be played in the future by coal-gas, gas-from-oil and natural gas, and the competitive power of the gas industry *vis-à-vis* solid fuel and electric current, have yet to be worked out. To a large extent it is a political as well as an economic matter.

The situation is changing so rapidly that any statistical statements must be out of date before they are printed; and it is also true that an enormous upheaval in the gas industry is inevitable as a result of the changing sources of raw materials. In 1968, just over 20 per cent of the raw materials used in gas works was natural gas, and about two-thirds of this came from the North Sea; another 52 per cent comprised oil, whilst coal, which only a few years previously had been accounting for two-thirds of the gas output, had dropped to only 23 per cent. The repercussions of this on the coal industry must be serious (see note under Fig. 149).

## Electricity

The following table shows the phenomenal growth of the electricity supply industry during the last few decades:

| YEAR | TOTAL OUTPUT IN MILLION kWh | (HYDRO) | (NUCLEAR) |
|---|---|---|---|
| 1929 | 11 962 | 165 | — |
| 1938 | 25 708 | 988 | — |
| 1946 | 42 742 | 1 139 | — |
| 1955 | 94 076 | 1 701 | — |
| 1966 | 202 568 | 4 560 | 21 009 |

### Thermal generation—coal and oil fuel

Until 1926 the systems of supply of electricity in this country were the result of unplanned growth. Local legislation and piecemeal development had

resulted in the existence of numerous isolated area supplies with a great variety of generating plant, frequencies and pressures. Two inevitable consequences followed—a very wide variation in the cost to the consumer of a unit of electricity and a paralysing or stultifying effect on large-scale developments. The Electricity Supply Act of 1926 provided for the setting up of a Central Electricity Board. Within this national scheme electricity was to be generated only at 'selected stations' where generation could be most economically carried out. The network of lines for the transmission of energy at high tension (commonly known as the Grid) rapidly became familiar through the erection of pylons in all parts of the country, and over these lines took place the 'wholesale' transmission of the current to the distributing undertakings. In 1948 the whole passed under the control of the British Electricity Authority. The Electricity Act of 1957 set up a Council, a Generating Board and twelve Area Boards in England and Wales. In Scotland the South of Scotland Electricity Board controls supplies in the Lowlands and Southern Uplands, whilst the North of Scotland Hydro-Electric Board looks after the Highlands.

The main location factors[1] involved in the distribution of power stations are: (1) proximity to the populous areas which the station is designed to serve; this is still important, but with the possibility of large-scale transmission of power at high tension over long distances it is much less so than formerly; (2) the availability of cheap coal, usually of inferior quality, or of fuel oil; water transport facilities, inland or coastwise, are of great importance. In addition to these *location* factors, there are two *site* factors of importance, the availability of cooling water, usually many millions of gallons per hour, and cheap land with room for expansion and for railway sidings and ash disposal. Water front sites will again be important; if adequate river or sea water is not available, large concrete cooling towers will have to be built (Plate 11), so that the water can be used over and over again.

*CEGB (England and Wales) power stations and capacity, 1968*

| TYPE OF INSTALLATION | NO. OF STATIONS | INSTALLED CAPACITY (MW) |
|---|---|---|
| Steam (coal or oil) | 179 | 40 000 |
| Gas turbine | 8 | 1 235 |
| Diesel | 12 | 52 |
| Nuclear | 7 | 3 300 |
| Hydro | 10 | 479 |
| Total | 216 | 45 020 |

1. See E. M. Rawstron, 'The distribution and location of steam-driven power stations in Great Britain', *Geography*, **36**, 1951, 249–62.

Until the Second World War the map of power stations bore some resemblance to a map of major urban concentrations, but postwar technological developments in the utilisation of pulverised coal, in the construction of large power stations with capacities undreamt-of a few decades ago, and in the transmission of high-tension current, have wrought great changes. Of the 179 steam-driven stations, about 40, each rated at over 300 MW (and the largest at 1770 MW), now possess about 67 per cent of the entire generating capacity (Fig. 151). To such an extent is the proximity of a large river now a matter of vital importance that 65 per cent of this 'super-station' capacity is now to be found alongside the lower Thames (5574 MW in ten stations), along the Trent (7638 MW in nine stations), and along the Aire and Calder (4120 MW in seven stations). These 'super-stations' almost all consume pulverised coal—of which the Yorkshire–Nottinghamshire coalfield is the cheapest source in the country—and their thermal efficiency is between 25 and 34 per cent, compared with less than 20 per cent and sometimes even less than 10 per cent for the older stations which are being gradually eliminated or relegated to a stand-by function only, the base load being taken by the big and efficient plants.

The other major development has been the 'super-grid', first of 275 kV and more recently (since 1966) of 400 kV. The total extent of the grid is about 16 000 kilometres (10 000 miles), of which 2575 kilometres (1600 miles) are 275 kV and 2100 kilometres (1300 miles) are 400 kV. The development of the 'super-grid' is a natural consequence of (1) the economies to be reaped by high-voltage transmission (even though this means bigger pylons), and (2) the concentration of the 'super-power' stations in the Trent valley, Yorkshire and Thames-side. Lancashire, still largely served by a multitude of relatively small stations, is increasingly the recipient of current from the Trent valley and West Yorkshire; and the 'super-grid', fed also by the nuclear power stations (see below), now extends to South Wales, southern and southwest England, and the northeast, with both west and east coast links into Scotland.

## Thermal generation—atomic energy and nuclear power stations[1]

In conventional steam-driven electric power stations a 'fossil fuel', such as coal, oil, or natural gas, is mixed with air and burned in a boiler furnace. The hot gases of combustion rise and go through tubes in a boiler through which water circulates. The water absorbs the heat and changes to steam, which is then used to drive a turbogenerator, thereby producing electric power. In nuclear power stations, the heat comes from the process of nuclear fission in an atomic reactor and, in British stations, carbon dioxide gas under pressure is pumped over the uranium fuel in the reactor, drawing off the heat to the boilers.

1. This section has been contributed by Dr P. R. Mounfield.

In the early 1950s, it seemed that Britain was faced with a future shortage of coal and oil for electricity generation. Thus, the first programme for the commercial development of nuclear power was introduced, in 1955, and under this programme it was planned to install 5000 MW of nuclear generating capacity by 1969. The power stations constructed under the programme have been based on the 'Magnox' thermal reactor design, first developed at Calder Hall in Cumberland, using natural uranium as a fuel. Nine stations of this type have been built. Three are on the Severn estuary, at Berkeley (276 MW), Hinkley Point (500 MW) and Oldbury (600 MW);

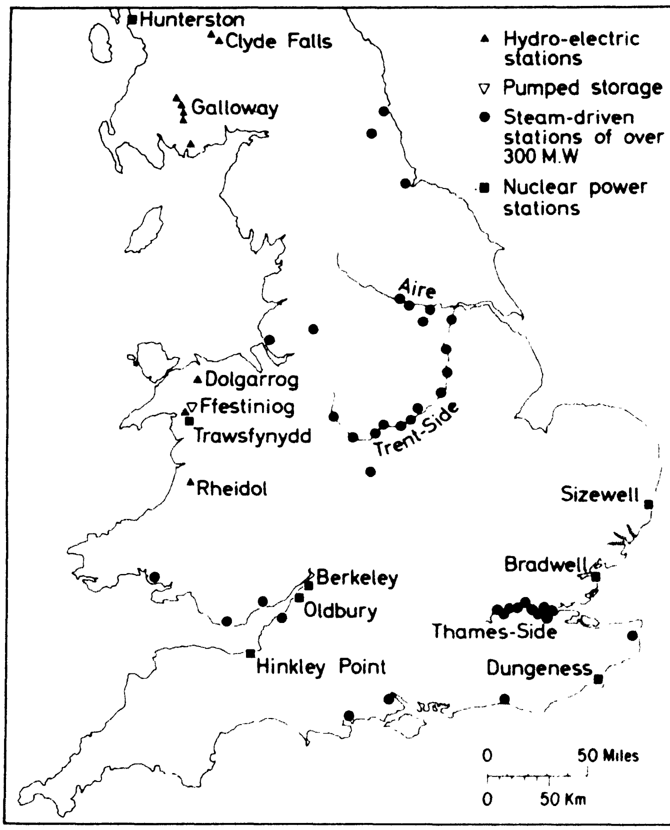



FIG. 151. Power stations, 1968

Of the 216 power stations in existence in England and Wales, 50 are shown on this map, including all the steam stations with over 300 MW capacity. The concentration of the latter on the Trent and the lower Thames is very striking

two are on the coast of East Anglia, at Bradwell in Essex (300 MW) and Sizewell in Suffolk (580 MW); two are in North Wales, at Trawsfynydd in Merioneth (500 MW) and Wylfa in Anglesey (1180 MW); one is on the south coast, at Dungeness in Kent (550 MW) and one in Scotland, at Hunterston, Ayrshire (300 MW). Because these stations have been costly to

build, the electricity that they produce is more expensive than that from coal-fired stations of comparable age and size located on the cheap coalfields. Thus, they have been located so as to meet the growth of demand for electricity in areas where coal is scarce or expensive, i.e. the southwest, the southeast and the northwest. Within these areas, two other important considerations have influenced the selection of sites. Because of the need for large quantities of water, each of the stations, except for Trawsfynydd, is on the coast. Also, though it is claimed that no danger is involved, to allay public fears on this score, sites far from large concentrations of population

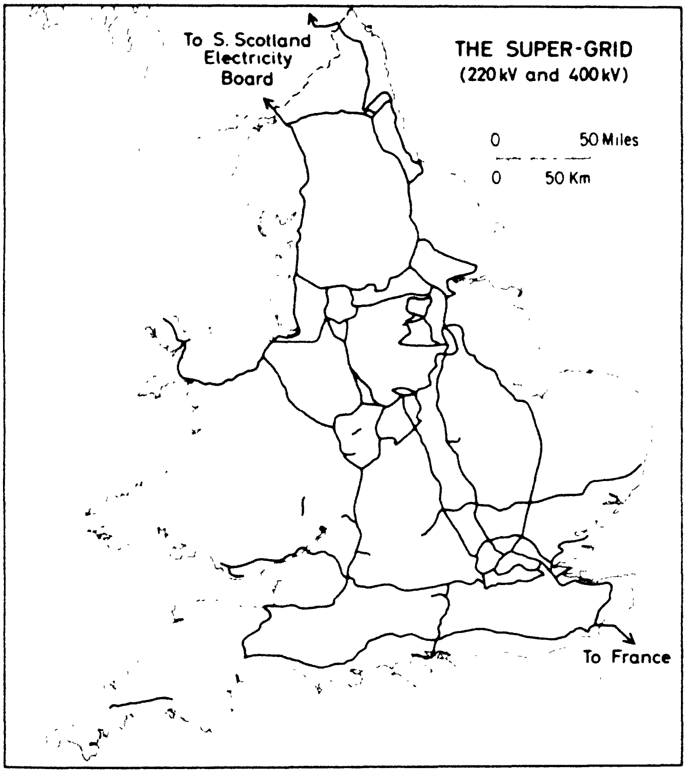



FIG. 152. The super-grid in 1968

Numerous extensions are proposed or in course of construction, the map can be kept up-to-date from the annual statistical yearbook of the Central Electricity Generating Board

have been selected. On occasion, this policy has led to conflict between the Central Electricity Generating Board and those bodies concerned with preserving the little that remains of rural Britain. It has also meant that rather long and expensive high-voltage transmission lines have had to be built to connect some of these remote stations to the national grid.

In April 1964 the Government announced Britain's second nuclear

power programme, for the period 1970 to 1975, allowing for the construction of a further 8000 megawatts of generating capacity. This programme was prefaced by an invitation from the Generating Board for tenders for all types of commercially available nuclear generating systems, including water reactors developed in the USA. Assessment of the tenders in July 1965 showed that the British advanced gas-cooled system (AGR) was the most commercially attractive design and AGR power stations, each of 1320 MW installed capacity, were under construction in 1969, on the same sites as the existing Magnox stations, at Dungeness, Hinkley Point and Hunterston, and at a new site at Seaton, near Hartlepool. A further station is proposed at Heysham on the Lancashire coast, together with a second station at Sizewell and a very large one of 2500 MW near Connah's Quay on the Dee estuary in North Wales.

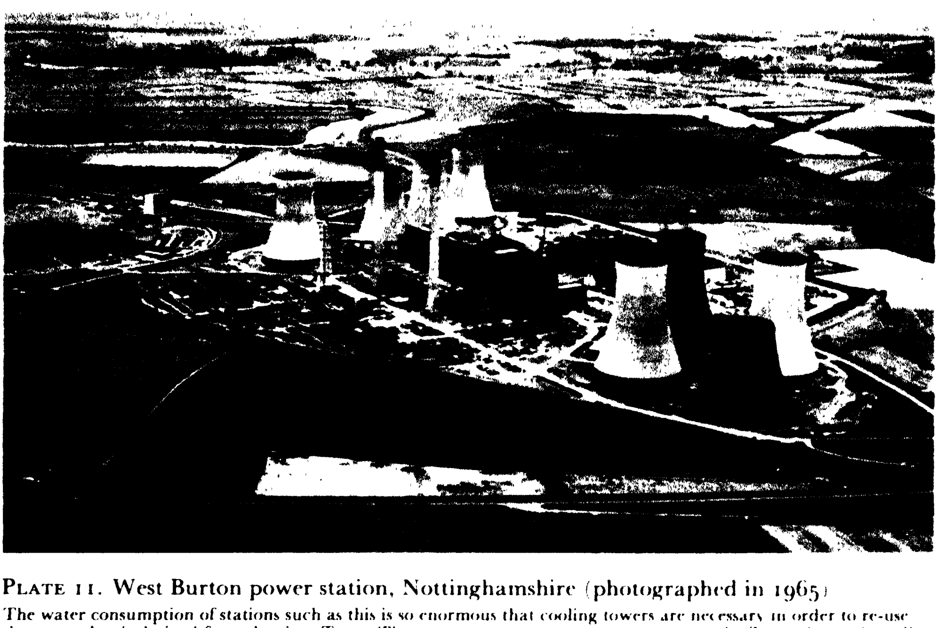


PLATE 11. West Burton power station, Nottinghamshire (photographed in 1965)
The water consumption of stations such as this is so enormous that cooling towers are necessary in order to re-use the water that is derived from the river Trent. There are now so many power stations on the Trent that if they all simply extracted river water and discharged it at a high temperature after use the river would consist of hot water, with disastrous consequences for the aquatic fauna

The estimates of the cost of electricity to be produced by the AGR plants have altered the economic conditions under which the locations for nuclear power stations are chosen. By the early 1970s, the AGR plants are expected to generate electricity more cheaply than the best coal or oil-fired power stations available at that time—more cheaply, even, than contemporary coal-fired stations built next to the pit head on the low-cost coalfields. Thus,

as nuclear power becomes progressively cheaper compared with power from fossil fuels, it will become increasingly appropriate to choose sites near to large cities and conurbations. This will enable increases in demand for electricity to be met with the minimum long-distance energy movements and with a minimum of new overhead transmission lines, and it will reduce the friction between the Generating Board and amenity preservation bodies. It is fortunate that, through the use of prestressed concrete pressure vessels, and oxide fuel in stainless steel cans, the AGR has excellent safety characteristics. In March 1968 the independent Nuclear Safety Advisory

PLATE 12. Dungeness nuclear power station (photographed in 1964)

Committee advised the Government that, in its opinion, it is safe to use sites near to large urban areas for AGR power stations. The locations that have been chosen to date for several of the AGR units reflect the fact that there is sufficient space at most of the existing nuclear power station sites for a second station, but the new locational parameters have influenced the choice of Heysham and Seaton and doubtless will be reflected in the choice of future sites.

In economic terms, the choice between nuclear and fossil-fuel electricity generation in Britain rests mainly on the advance of nuclear technology on

the one hand, and future movements in the cost of conventional fuels on the other. In 1970 three-quarters of the electricity produced in Britain will come from coal-fired power stations, with the remaining quarter divided almost equally between nuclear and oil-fired plants. However, the new generating plant commissioned and provisionally planned to be commissioned by the Generating Board up to 1980 is as follows:

| PERIOD | CONVENTIONAL (MW) | NUCLEAR (MW) | GAS TURBINE AND HYDRO-PUMPED-STORAGE (MW) |
|---|---|---|---|
| 1961–5 | 8 638 | 2 415 | 1 069 |
| 1966–70 | 21 666 | 2 670 | 800 |
| 1971–75 | 8 000–11 000 | 6 000– 7 000 | 2 000–3 000 |
| 1976–80 | 6 000–11 000 | 16 000–20 000 | 2 000–3 000 |

These figures underline the fact that nuclear power is now a strongly competitive source of electrical energy. During the 1970s it will be taking an increasing share of the base load generation of electricity and it seems possible that by 1980 a very large proportion of the Generating Board's *new* capacity may be nuclear. There are, however, many imponderables. For example, in January 1968 a 60 MW unit using natural gas from the gas grid was commissioned at Hams Hall power station, near Birmingham, and some further use of North Sea gas in power stations seems inevitable, for it will be cheaper than coal in many areas. Yet again, a substantial reduction of the fuel oil tax would make oil the cheapest fuel for electricity generation in most parts of the country. Since they are twice as expensive to build as conventional stations of the same size, nuclear power stations are particularly vulnerable to rising interest rates, but on base load, the fuel cost of a modern conventional station is about two-thirds of the total generating cost. At a nuclear station it is only about one-fifth. The Seaton AGR power station provides an example of what this can mean in practical terms. Assuming an average load factor of 75 per cent, the estimated overall cost of generation at the Seaton AGR station is 0.52*d* per unit, compared with 0.70*d* per unit for a coal-fired station at the same site burning Durham coal. The National Coal Board's price increases of April 1966, added £30m to the electricity industry's fuel bill, and it could well be that, in the light of rising coal prices, some increase in the nuclear power programme before 1975 would be economically justified. Even if this does not happen, by 1975 nuclear power stations will be providing a quarter of the total electrical power produced in Britain.

If current plans remain unchanged, the total nuclear capacity in Britain in 1975 will be 13 000 megawatts; approximately one-fifth of the total generating capacity then installed. Such a large commercial reactor programme requires the support of extensive nuclear fuel services. Uranium ore has to be mined and the uranium extracted and concentrated. These activities are carried out in Canada, the USA, Australia and other uranium

producing countries, but large chemical plants are required for the conversion of the uranium concentrate to metal or to the gaseous compound uranium hexafluoride, which is the feed material for isotope separation plants. The latter are required to enrich uranium and, although the Magnox reactors use natural uranium, the fuel elements for the AGR stations will contain uranium in slightly enriched form. A publicly owned company may well be formed soon to take over the responsibility for nuclear fuel, but at present the production group of the United Kingdom Atomic Energy Authority (AEA) provides all the services except mining and concentration of ore. The AEA developed out of the organisation originally formed to produce Britain's military nuclear deterrent and consequently owns the Springfields factory for the treatment of imported uranium ore concentrate and fabrication of fuel elements, the Capenhurst gaseous diffusion plant and the Windscale fuel reprocessing plant. In addition, it has extensive research and development facilities, particularly at Harwell and Winfreth Heath, and operates the Calder Hall, Chapelcross and Dounreay reactors. The Authority's factories have been largely rebuilt and re-equipped to supply the fuel services for CEGB. The existing Magnox reactors already have been supplied with over 1.7 million fuel elements made at Springfields and when all nine stations are fully operational replacement elements will be supplied at a rate of 150 000 a year. Completely new manufacturing facilities are being provided at Capenhurst for the fabrication of the slightly enriched fuel elements for the AGR stations. A large new reprocessing plant has been built at the Windscale site which has a capacity for treating more than 2000 metric tons a year of irradiated fuel. The Generating Board itself has a comprehensive nuclear power research unit at its Berkeley Nuclear Laboratories, on the river Severn between Bristol and Gloucester. These laboratories provide the electricity supply industry with basic technical and scientific information. The site for the laboratories was chosen for its proximity to one of the Generating Board's early nuclear power stations and because it was close to the University of Bristol.

## Hydroelectricity

The Water Power Resources Committee Report of 1921, referred to above, foresaw, on the basis of schemes proposed at that time, the development of no more than 250 MW of hydroelectricity, the bulk of which would come from Scotland. True, all the physical possibilities had not then been investigated, and in fact by 1968 more than 1600 MW of generating capacity was actually in existence—but even so, these figures pale beside the 45 000 MW of thermal-electric capacity installed in England and Wales alone in 1968, and the energy output figures given above (p. 337) show that hydroelectricity represents but one-fiftieth of the total electricity output.

The fact is of course that the physical make-up of Great Britain does not

*lend itself to large hydroelectric developments. There is plenty of well* distributed rainfall in Highland Britain, and there are plenty of swiftly falling rivers, but the available catchments are very small and so the capacity of any plant, even allowing for considerable reservoir construction to augment the supplies, is bound also to be small.

There are really but few possibilities. Clearly the best area is the western side of the Scottish Highlands, where rainfall is heaviest and the relief greatest; but there are also possibilities in the western part of the Southern Uplands. The Lake District is of no use since the catchments are very small and the lakes are at too low an altitude. Snowdonia and the western part of central Wales hold some prospects, and there are minute possibilities in the Dartmoor area. But that is all. In Ireland the existence of the large river Shannon has opened up a possibility of a rather different kind.

Developments in the Scottish Highlands date from 1895. The earliest station was erected at Foyers, on the eastern side of Loch Ness, for the smelting of aluminium. The years 1904–09 witnessed the erection of a 23 MW power station at Kinlochleven, at the head of a marine loch, to which seagoing steamers have access. The water comes from the Moor of Rannoch to the east. Quite a considerable town has grown up around the aluminium works, now belonging to the British Aluminium Company, which were established. The Lochaber Power Company, established in 1921, achieved fame by driving a fifteen-mile tunnel to carry water from Loch Trieg through the flanks of Ben Nevis to near Fort William, there to generate electricity for the British Aluminium Company's smelter built just north of the town in 1929. Lochs Trieg and Laggan were dammed to increase their storage capacity, and the headwaters of the river Spey diverted into Loch Laggan.

The Grampian system, dating from 1930, comprised two power stations utilising the abundant water supply of the great Rannoch upland. The Rannoch installation uses water from Loch Ericht; the Tummel station uses water from Loch Rannoch. Much farther north, in Ross-shire a small station at Loch Luichart used water from the river Conon, and supplied power to Nairn, Dingwall, and Dornoch. The Highlands of Scotland have certain advantages for water development. Temperatures are moderate so that risk of freezing is slight, evaporation is low, and hence the loss of water from reservoirs is small. Moreover, the winter precipitation maximum (even though part of it may be in the form of snow and so not immediately available) ensures that the river flow is greatest just when the demand for electricity is at its highest. There are many sites suitable for dams, and considerable areas are more than 900 metres (3000 ft) above sea-level so that a good fall of water is possible. But it became clear that a fully coordinated development was essential.

Under the Hydro-Electric Development (Scotland) Act 1943, a public authority was set up known as the North of Scotland Hydro-Electric Board which was given wide powers for the development of water and the pro-

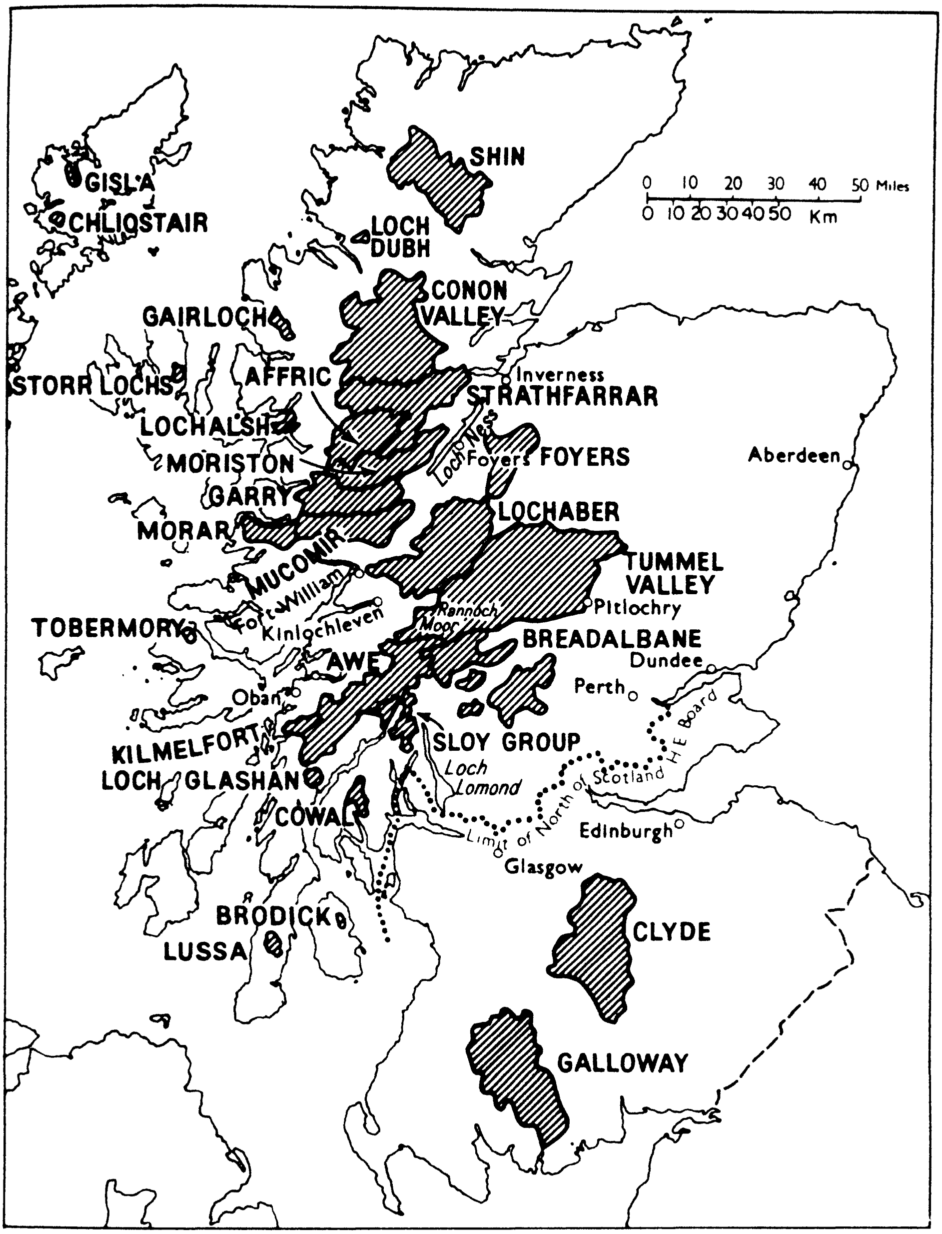



FIG. 153. Map of Scotland showing water-power development—projects and catchment areas

motion of social, industrial, and general rehabilitation within the Scottish Highlands. Its area of operations covers about 57 000 square kilometres (22 000 square miles), approximately three-quarters of Scotland, and is

broadly the whole area north of the Central Lowlands (see Fig. 153). The Electricity Act 1947, which nationalised the electricity supply industry in Britain, left the Board out of the pattern for the rest of the country but brought under its control the sixteen existing private and local authority undertakings. The Board is required not only to produce and sell electricity

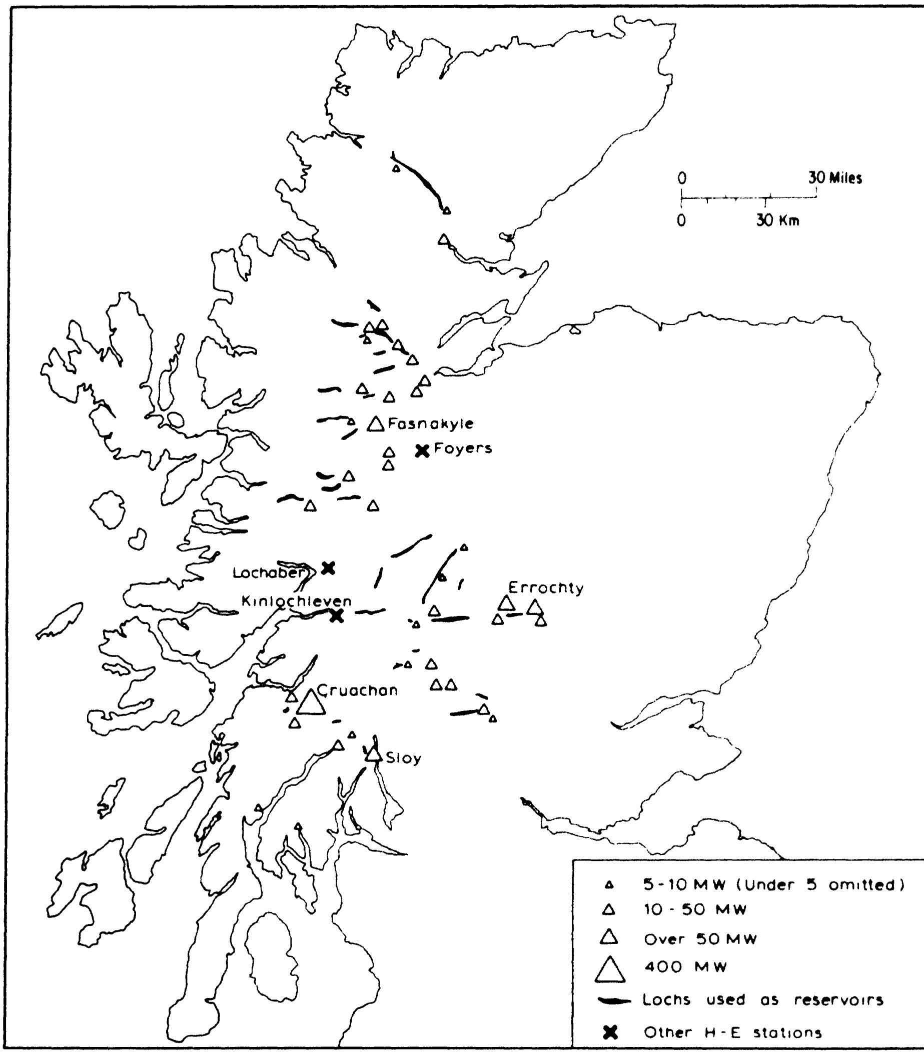



FIG. 154. Water power in the Scottish Highlands
Based on data from the North of Scotland Hydroelectric Board.

but to collaborate in measures for the social and economic development of the whole area.

The first of the new hydroelectric power stations to be completed was a

very small one at the Falls of Morar in Inverness-shire in 1948. At that time only one farm in fourteen and one croft in a hundred were connected to the mains. The large Loch Sloy scheme with its power station on Loch Lomond was completed in 1950, and the Glen Affric scheme, with a power station at Fasnakyle in Strathglass, was opened in 1952. By 1948 the Board had fifty-five main hydroelectric power stations in operation, all but two (Rannoch and Tummel) built since the war (Fig. 154). The installed capacity was 1047 MW and the output 3225 million units. The number of consumers was 444 000, or 96 per cent of the potential. The Board had built or rebuilt over 400 miles of roads.

The largest power station is the 400 MW pumped-storage station, part of the Cruachan (Loch Awe) scheme; the station itself is underground. The principle of this scheme is to have high level and low level reservoirs connected by a pipeline. At off-peak periods the water is pumped into the upper reservoir and then electricity is generated by allowing the water to flow from the upper to the lower reservoir through the turbogenerators at times of peak load. Among other large stations may be mentioned Errochty and Clunie in the Tummel valley. The latest big development is based on Foyers; the aluminium works having closed, the Hydro-Electric Board is to establish a 300 MW station by enlarging the catchment and using pumped storage. The project is due for completion in 1974.

Outside the Highlands of Scotland conditions are generally less favourable, potential and actual output is of limited magnitude, so that the British Electricity Authority controls a limited number of relatively small stations. One of the largest is the Galloway Scheme in the Southern Uplands, completed at the end of 1936, with five power stations, a generating capacity of 102 MW and an annual output of about 180 million units. Much earlier, however, the falls on the Clyde were harnessed to supply two power stations, one using the Stonebyres Falls and the other the Bonnington and Corra Linn Falls.

There are small hydroelectric power stations in North Wales at Dolgarrog, Maentwrog, and Cwm Dyli; the first of these provides power for an aluminium rolling mill (see p. 477). In 1963 a large pumped-storage scheme, with a capacity of 360 MW, was completed in North Wales (Ffestiniog) and in 1964 the Rheidol scheme near Aberystwyth, with two power stations and a capacity of 56 MW. There are three tiny stations in the Dartmoor area, two of which are in the Tavy valley north of Plymouth.

What is happening is in fact the coordination in the whole national grid system of what were formerly small isolated schemes, as well as some larger ones and extending or adding to them. Perhaps the most interesting possibility for water power lies in harnessing the energy of the tides. Of the various schemes which have been considered that of the Severn Barrage has attracted most attention and has been the most carefully investigated. Unfortunately the output, estimated at 2300 million units a year from a plant capacity of 800 000 kW, would be rather irregular as the height of the

tide varies. Capital cost was estimated at £29m in 1933, at £47m in 1944, and rising costs have since put the whole scheme virtually out of practical consideration.

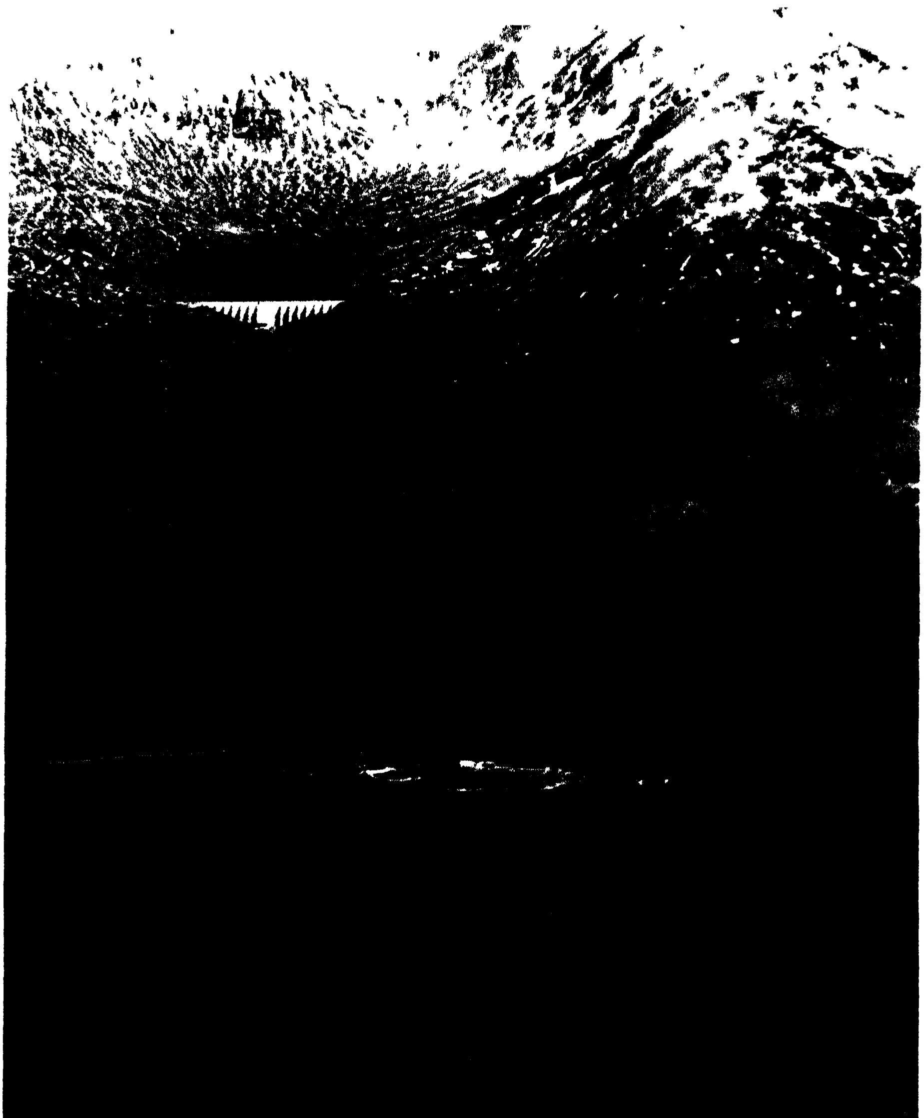


PLATE 13 Cruachan pumped-storage hydroelectric scheme, Argyll
The fall from the dam to the power station on Loch Awe is 365 metres (1200 ft)

## Water power in Ireland

Until the recent developments in the Scottish Highlands, by far the largest and most ambitious scheme in the British Isles was that for harnessing the river Shannon. Ireland is practically devoid of coal, and so was under the necessity of importing her fuel, hence the great incentive to the development of water power from the largest river in the British Isles. The Government entered into an agreement with a German firm—Messrs Siemens Schuckertwerke—in February 1924, the proposals being submitted to Dàil Eireann in 1925, and the Shannon Electricity Act was passed in June of the same year. The river Shannon has a long meandering course over the central drift-covered plain, passing through three large lakes, Loughs Allen, Ree, and Derg, and in 200 kilometres (125 miles) of its length has a

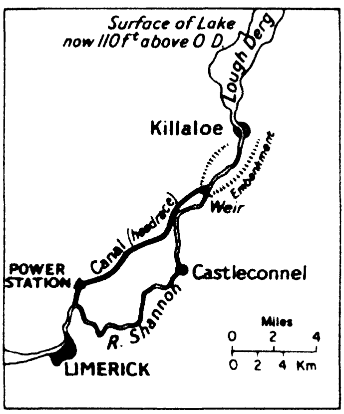



FIG. 155. Details of the Shannon scheme

fall of only 17 metres (55 ft), or less than 15 cm (6 in) per mile. The flow is sluggish, the flooding of adjacent areas common, but from Lough Derg to the sea a remarkable change takes place. The surface of Lough Derg was about 30 metres (100 ft) above mean sea level at Limerick and from Killaloe at the southern end of the lake to Limerick is only a distance of 24 kilometres (15 miles). The river made its way through a series of rapids, cutting almost a gorge through the hard rocks which there cross its bed. The local details of the scheme as carried out are shown in Fig. 155. By means of an embankment below Killaloe the surface of the lake was raised some 3 metres (10 ft) so that it is now 33 metres (110 ft) above O.D. Fortunately, Killaloe is built on rather higher banks of the river, and the little town has not suffered. At the southern end of the embankment a large weir was constructed, and then the bulk of the water taken through a canal or headrace to the power station just above Limerick where the full fall of nearly 30 metres (100 ft) could be utilised, the spare water being allowed to find its

way through into the Shannon. The power house is at Ardnacrusha, from whence the race discharges the spent water into the Shannon near Limerick. The water in the tailrace is influenced by the tide, the net fall varying from 26 to 35 metres (86 to 115 ft). Above Killaloe, throughout the Central Plain, the river is navigable and a barge canal was constructed at the side of the power works so as to permit continuous navigation from Limerick. Further

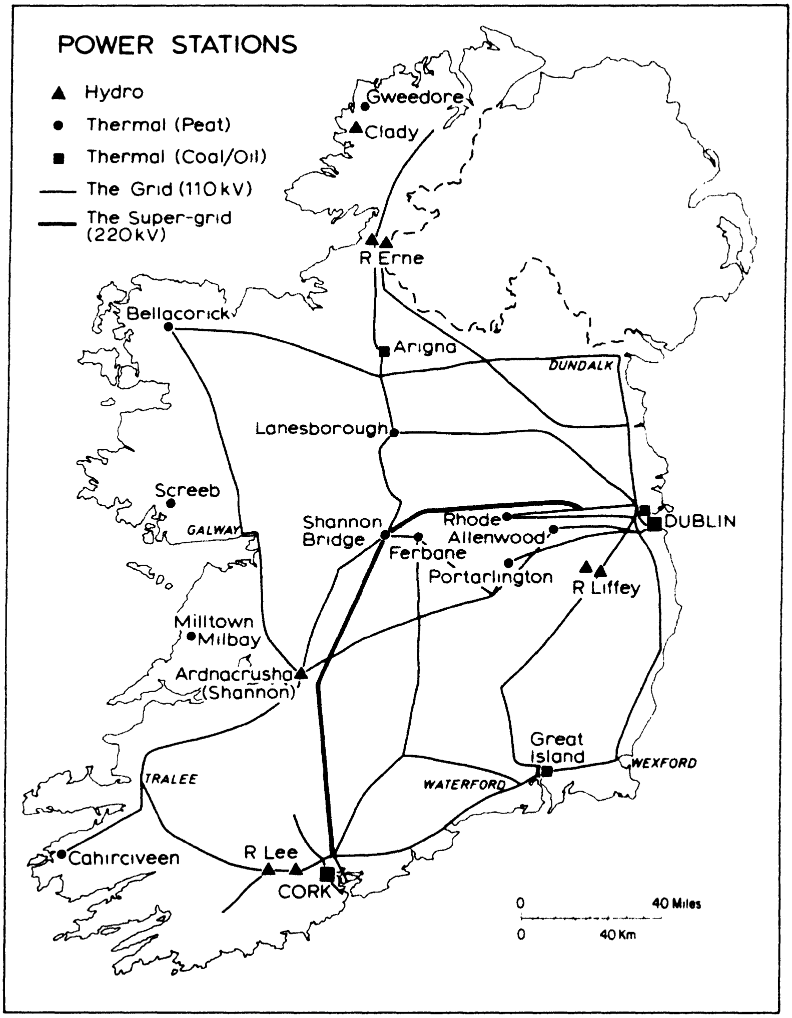



FIG. 156. The Irish electricity grid, 1968

This map can be kept up-to-date from the annual reports of the Electricity Supply Board, Dublin.

a small canal with a series of steps to be utilised by salmon was made (later much improved), since salmon fishing in the Shannon is of very considerable value. Under the Electricity (Supply) Act, 1927, the Electricity Supply

Board took over the task of generating and supplying electricity to the whole Republic. Fig. 156 shows the power stations which in the year ended 31 March 1968 generated 4 246 000 000 units, 19.5 per cent derived from water, 26.7 per cent from peat, 1.8 per cent from native coal and 52 per cent from imported coal and oil.

## Petroleum

The consumption of petroleum continues to rise by leaps and bounds, and the industry that supplies it has undergone a major revolution since the Second World War. In 1947 about 2.5 million metric tons of crude oil were refined in Great Britain; in 1968 ten major refineries each had an annual capacity greater than this, and four of them a capacity of over 10 million metric tons, whilst the output of saleable products reached an all-time record of 84.8 million metric tons (83.5 million long tons). The reasons for this vast expansion are partly economic, partly political and partly technological. Crude oil costs much less to import than refined petroleum, and the dollar shortage made it vital to cut American imports and increase the importation of crude oil from the Middle East. Political considerations were also involved: the Arab embargo on the export of Middle East oil to the refinery at the Israel port of Haifa, and the Persian seizure of Abadan, were both factors increasing the desirability of expanding British refining capacity; whilst the Suez crisis of 1956 spurred the development of supertankers that have reduced transport costs but have created port problems. Certain technical factors also played a notable part: the refineries produce many byproducts which can be used in other industries, and the petrochemical industries (cf. Chapter 22) have likewise rapidly expanded; and the variety of petroleum products now used by motor cars, tractors, diesel-engined lorries and locomotives, and aircraft is such that it is obviously more economic to produce them at home refineries from crude oil imported in vast bulk than to import them separately in small tankers that can only carry one product at a time.

*Users of oil fuels, 1967*

| | MILLION METRIC TONS | MILLION LONG TONS | | MILLION METRIC TONS | MILLION LONG TONS |
|---|---|---|---|---|---|
| Electricity generation | 7.9 | 7.8 | Bricks, pottery, glass, cement | 2.7 | 2.7 |
| Central heating | 5.7 | 5.6 | Chemical industries | 2.4 | 2.4 |
| Oil refining | 4.7 | 4.7 | Paper industry | 1.1 | 1.1 |
| Steel industry | 4.5 | 4.5 | Railways | 1.0 | 1.0 |
| Engineering industry | 3.1 | 3.1 | | | |
| | | | Total | 44.0 | 43.4 |

The 1968 output of 84.8 million metric tons (83.5 million long tons) included 44 million metric tons (43.4 million long tons) of gas oil, diesel oil

and fuel oil, 13 million metric tons (12.8 million long tons) of motor spirit, 3.1 million metric tons of aviation spirit, and 10 million metric tons of naphtha, used as 'chemical feedstock' in the petrochemical industry and in the manufacture of gas. The table on p. 353 lists the most important users of the heavier fuel oils.

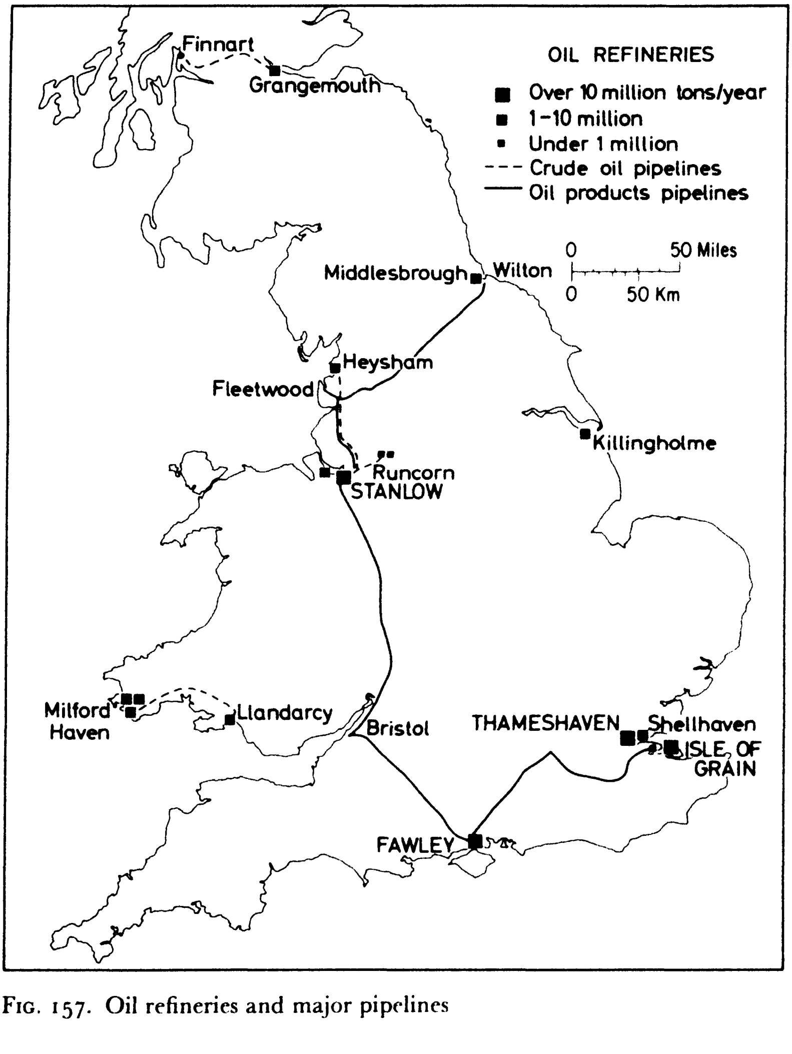



FIG. 157. Oil refineries and major pipelines

Naturally enough, waterfront situations are chosen for oil refineries, since all the crude oil is imported. But because they require very large areas and are somewhat undesirable neighbours, they have been built away from the major ports, and have had to develop their own port or pipeline facilities. Fawley is on Southampton Water, but its Solent approaches had to be dredged to enable fully-laden 70 000 ton tankers to reach it. Stanlow, on

the Manchester Ship Canal (which can only take vessels up to 12 000 tons) had to develop a new dock at Eastham to take 30 000 ton tankers, and a jetty (with a 19.3 kilometres (twelve-mile) pipeline) at Tranmere on the Mersey estuary for tankers larger than this. Thames Haven and Shellhaven on the Essex shore of the Thames estuary, and the Kent refinery on the Isle of Grain, can now accommodate very large tankers. Grangemouth, on the Forth estuary, is too shallow for large tankers, so a 92 kilometres (57-mile) pipeline was laid from Finnart on the 'fjord' of Loch Long which has very deep water close to the shore. At Llandarcy, near Swansea, the refinery (which dates from the 1920s) was served by Queens Dock, but as this cannot take vessels of over 20 000 tons a pipeline has been laid to Angle Bay on Milford Haven. Milford Haven has indeed been the scene of very important developments, for in addition to the Angle Bay terminal, three separate oil refineries have now been constructed along this 'ria', which can take 250 000 ton tankers. The search for deep-water facilities has gone on, and the latest refineries are on Tees-side, on the south bank of the outer Humber estuary (where the deep-water channel swings into the shore), and on reclaimed land at the entrance to Belfast harbour. Even more spectacular is the development of a terminal at Bantry Bay, one of the deep rias of southwest Ireland, where tankers of 300 000 tons or more can be accommodated, unloading their liquid cargo into smaller tankers which distribute to British and continental refineries.

The coastal location of the refineries also facilitates an export trade which is growing rapidly. In 1945 the export of fuel oil in ships' bunkers totalled 1.7 million metric tons, and of fuel oil not for bunkers, only 1000 metric tons. By 1951 the figures had risen to almost 3 million metric tons for bunkers and 2.3 million metric tons not for bunkers; whilst in 1968 bunkers totalled 5.5 million metric tons and other exports 13.0 million metric tons

# 15
# Mining industries other than coal and iron

The tables below show the relative importance, in terms of output and employment, of the various minerals that are mined and quarried in the United Kingdom. As already noted, coal is still by far the greatest, but gravel and limestone are fast catching up. It is significant that this mid-twentieth-century 'age of concrete' demands increasing quantities of aggregate (sand and gravel) and of cement (made from limestone and chalk); significant also that, unlike coal, most of the other minerals are obtained by quarrying, the effect of which on the landscape rivals that of the collieries and their spoilheaps and is geographically more widespread.

*Output of minerals*

| MINERALS | PRODUCTION (MILLION TONS) | | | | | |
|---|---|---|---|---|---|---|
| | 1938 | | 1955 | | 1967 | |
| | METRIC TONS | LONG TONS | METRIC TONS | LONG TONS | METRIC TONS | LONG TONS |
| Coal | 230.6 | 227.0 | 225.1 | 221.6 | 173.8 | 171.5 |
| Iron ore | 12.0 | 11.9 | 16.4 | 16.2 | 12.9 | 12.7 |
| Chalk | 10.5 | 10.4 | 16.6 | 16.5 | 18.1 | 17.9 |
| Limestone | 19.1 | 18.9 | 31.7 | 31.2 | 76.3 | 75.2 |
| Igneous rocks | 12.0 | 11.9 | 14.1 | 14.0 | 29.8 | 29.4 |
| Slate | 0.3 | 0.3 | 0.15 | 0.15 | 0.1 | 0.1 |
| Sandstone[1] | 5.2 | 5.2 | 4.4 | 4.4 | 8.9 | 8.8 |
| Salt | 2.6 | 2.6 | 4.7 | 4.7 | 7.1 | 7.0 |
| Clay, shale, etc. | 27.2 | 26.8 | 29.7 | 29.3 | 35.2 | 34.7 |
| China clay | 0.6 | 0.6 | 1.2 | 1.2 | 2.6 | 2.6 |
| Potters clay | 0.2 | 0.2 | 0.4 | 0.4 | 0.5 | 0.5 |
| Fireclay | 2.6 | 2.6 | 2.5 | 2.5 | 1.7 | 1.7 |
| Sand and gravel | 22.5 | 22.2 | 60.4 | 59.5 | 107.0 | 105.4 |
| Oil shale | 1.5 | 1.5 | 1.3 | 1.3 | nil | nil |
| Tin ore (dressed) | 0.003 | 0.003 | 0.002 | 0.002 | 0.002 | 0.002 |
| Lead and zinc ore (dressed) | 0.057 | 0.057 | 0.011 | 0.011 | 0.005 | 0.005 |
| Moulding sand | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 |
| Gypsum (including anhydrite) | 1.1 | 1.1 | 2.9 | 2.9 | 4.5 | 4.5 |

[1] Including silica rock and ganister.

*Employment in mines and quarries*

| | 1927 | 1935 | 1948 | 1967 |
|---|---|---|---|---|
| Coal mines | 1 023 886 | 769 474 | 727 565 | 412 000 |
| Iron ore mines and quarries | 11 864 | 7 981 | 6 529 | 3 227 |
| Other metalliferous mines | 5 137 | 3 409 | | 941 |
| Salt works | 97 399 | 84 100 | 4 824 | * |
| Slate quarries | | | 4 724 | 1 377 |
| Other non-metalliferous mines and quarries | | | 39 133 | 42 065 |

Not including clerical and other non-operative staff.
* Not available.

In general terms we can divide the 'other minerals' into two groups, metallic and non-metallic. Any consideration of metallic minerals in Britain (other than iron ore) must now be largely a matter of historical geography, for, important though Cornish tin, Anglesey copper, Pennine lead, for example, may once have been, present outputs are either nil or very small in quantity. Nevertheless a brief résumé may not be out of place. The industrial significance of the minerals in question will be considered in Chapter 18.

## Metallic ores

Although individual deposits may vary widely in details of their mode of occurrence most of the metallic ores found in Britain may be said to occur in one of three major types of geological environment:

(*a*) Associated with the granite masses of Devon and Cornwall.
(*b*) In the Lower Paleozoic rocks of the Highland Zone of Britain, associated with igneous activity of which sometimes there is no evidence at the surface—as in central and north Wales (including Anglesey), the Welsh Border (Shropshire), the Lake District, the Southern Uplands of Scotland, and the Wicklow Mountains of Ireland.
(*c*) In certain regions of the Carboniferous Limestone outcrop, such as the Derbyshire Dome, the northern Pennines of northwest Yorkshire, Durham and Northumberland, the Mendip Hills, and the hills of northeastern Wales (Flintshire).

### Devon and Cornwall[1]

One of the later stages of the igneous activity which produced the Armorican granites of Devon and Cornwall was the intrusion of veins and lodes carry-

1. See H. G. Dines, *The Metalliferous Mining Region of South-west England,* Mem. Geol. Surv., HMSO, 1956.

ing metalliferous ores, which are found chiefly in a belt about 9.5 to 16 kilometres (six to ten miles) wide extending from Lands End to Dartmoor (Fig. 158). In general, tin and copper occur nearest to the granites; lead, silver, and zinc farther away. Tin ore (cassiterite) is a very stable mineral and so was to be found not only in the original veins or lodes in the rocks, but also washed out in alluvial gravels, where it was formerly worked as

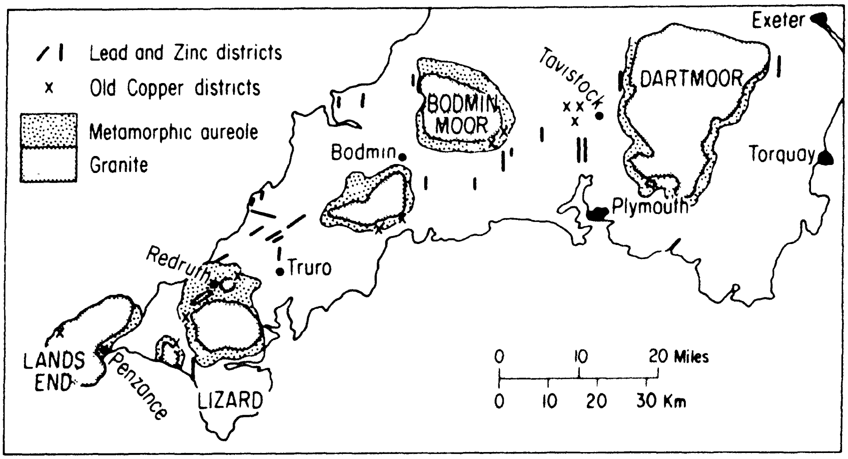



FIG. 158. The metalliferous mineral areas of Cornwall and Devon
The tin-mining tracts corresponded approximately with the copper districts

'stream tin'. Cornwall was almost the world's only source of tin from very early times until the early nineteenth century. The greatest concentration of mining was around Camborne and Redruth. Copper was also mined from pre-Roman times in several districts of the southwestern peninsula, and Cornish ores contributed in no small measure to the rise of Swansea as the world's greatest copper-smelting centre in the early part of the nineteenth century (cf. p. 465). Mining in Devon and Cornwall is but a shadow of its former self; one or two mines remain productive of tin, wolfram (tungsten ore), and arsenic, but though it is considered by some that much mineral wealth remains to be got, there is unlikely to be any revival without an enormous programme of reorganisation and exploration and the application of vast new capital resources.[1]

## Wales, etc.

The Lower Paleozoic rocks of Wales, the Lake District, and the Southern Uplands, have yielded a number of different minerals, but particularly

1. See *Memorandum to the Minister of Reconstruction on the production of non-ferrous metals and minerals other than coal in Great Britain*, published by Institution of Mining and Metallurgy, 1944. In 1968 several firms were prospecting in West Cornwall.

lead, which was worked from Roman times. The most important areas were in central and North Wales, in the Welsh Border district (Shelve in Shropshire), in the Lake District, and in the Leadhills district of the Southern Uplands. Copper was also occasionally important, as in North Wales and Anglesey (Parys Mountain), and in the Lake District (Keswick area). A little gold has been obtained from the Dolgellau area of North Wales and from Carmarthenshire; and the manganese ore found in the Cambrian rocks of North Wales has been worked from time to time, especially during the two World Wars.

**Ireland**

The Armorican disturbances induced mineralisation in the Paleozoic rocks of southern Ireland, at intervals in a broad belt from the Wicklow Mountains to the mountains of Kerry and in the Paleozoic uplands of Tipperary and Galway. Apart from much past working, there has been a recent resurgence, backed by Canadian and American capital, with new developments in copper in the Wicklow Mountains, in silver-lead-zinc at Tynagh in Co. Galway (now the largest producer in Europe) and in copper-lead-zinc-silver and barytes in the Silvermines Mountains of Tipperary.

**Regions of the Carboniferous Limestone outcrop**

Fissures and solution hollows in the Carboniferous Limestones are frequently filled with mineral deposits, of which lead and zinc have been most important. Five main lead-fields have been worked, in the Alston–Allendale area of the northernmost Pennines, farther south in northwest Yorkshire, in the Derbyshire Dome, in the Mendips, and in the limestone hills which border the Flint and Denbigh coalfield. In most of these areas the maximum output was reached after the middle of the nineteenth century and a very rapid decline followed; but evidence of the industry, in the shape of old mine shafts, spoil heaps, and tumbledown buildings, is still to be found in places. In 1958 a lead mine near Matlock was the only one working in the country. Zinc ores were associated with the lead veins in some places, particularly in the Mendips and in North Wales. Occasionally, copper ores occurred, as on the western edge of the Derbyshire Dome at Ecton, in Staffordshire. In Ireland, lead and zinc have been worked at many localities on the fringes of the Central Lowland, e.g. in the counties of Sligo, Clare and Monaghan.

## Non-metallic minerals

We may divide the non-metallic minerals into two groups, the rarer and more highly localised ones—e.g. salt, gypsum, and anhydrite, fireclay and

ganister, fluorspar, china clay—and the commoner and more widespread ones—e.g. limestone, chalk, brick clays, sandstone, igneous rocks (granite, whinstone, etc.) slate, sand, and gravel. Another way of distinguishing the two groups might be to say that of the first group more or less all of the available deposits are likely to be ultimately required, whereas in general, and from a national rather than a local point of view, there is a wider choice of locality for the working of the commoner minerals.[1] One can hardly envisage the extraction and utilisation of the entire chalk outcrop, for example!

Except for the igneous rocks, which are quarried mainly for road metal, all the non-metallic minerals occur in the sedimentary rocks, and every formation from the Cambrian to the Pleistocene yields some mineral or other in some part of its outcrop.

## The 'rarer' minerals

The semi-desert conditions under which the later Permian and Triassic rocks were laid down were responsible for the accumulations of salt, gypsum, and anhydrite which are now worked in Cheshire, in South Durham, and elsewhere.

*Salt.*[2] Rock-salt used to be mined in Cheshire, and still is in one mine at Winsford, but almost all our salt output is now obtained by controlled brine-pumping.[3] There is an enormous reserve underneath the Cheshire Plain — the salt beds are several hundred metres in thickness over an area of some 970 square kilometres (375 square miles) — and the great chemical industries (p. 584) which depend on the salt need have no fear of exhausting the supplies. Other salt deposits occur in the Trias in the vicinity of Stafford, Droitwich (Worcs.), Fleetwood (Lancs.), and Middlesbrough.

*Gypsum*[4] (calcium sulphate $CaSO_4$, $2H_2O$) is the raw material of plaster of Paris and of the plasterboard which plays such an important part in the building industry. It is quarried or mined in Nottinghamshire (e.g. at Gotham and near Newark), in Staffordshire (near Tutbury), and in the Eden Valley near Appleby; there is also a mine near Battle, in Sussex,

1. This contrast should not be pushed too far; to an increasing extent modern industry requires specialised and standardised products which can often only be obtained from relatively small areas, and the availability of transport and markets exerts a very strong influence over the location of quarries.

2. A. F. Calvert, *Salt in Cheshire*, London, 1915; also *Mem. Geol. Surv., Mineral Resources*, vol. xviii, *Rock-salt and brine*, HMSO, 1921.

3. Pumping of 'wild' brine from the old and flooded salt-mines led to considerable and unpredictable surface subsidence—now represented by 'flashes' or lakes, especially in the Northwich district; controlled pumping does not eliminate subsidence, but reduces it and renders it more or less predictable, by confining it to the vicinity of the bore-hole. About 65 per cent of the brine pumped in Great Britain is obtained from bore-holes on the Holford estate, about 8 kilometres (5 miles) east of Northwich.

4. *Mem. Geol. Surv., Mineral Resources*, vol. iii, *Gypsum and anhydrite*, HMSO, 3rd edn, 1938.

which works gypsum from the Purbeck Beds (Upper Jurassic). The anhydrous form of gypsum is known as *anhydrite*; it is an important raw material for certain branches of the chemical industry, notably the manufacture of ammonium sulphate and sulphuric acid (cf. p. 585). Almost the entire output comes from a large mine at Billingham-on-Tees around which, since the 1930s, the vast works of Imperial Chemical Industries have grown up, and from near Workington in Cumberland.

*Potash.* Deep borings (to 1220 metres (4000 ft) or more), sunk originally in the search for oil, in the North Yorkshire Moors area, in the vicinity of Whitby, have revealed what is probably the western edge of the great Upper Permian ('Zechstein') potash field that reaches its greatest expression in the Stassfurt area of Germany. The first mine sinking was commenced in 1969 at Boulby, and others are likely to follow.

*Fluorspar*,[1] used as a flux in the steel industry and in the manufacture of hydrofluoric acid for glass-etching, is obtained from veins in the lead-bearing districts of the Carboniferous Limestone outcrop; the main present source is Derbyshire.

*China clay and China stone*[2] are derived from the decomposition (probably by superheated gases and steam from below) of certain of the granite masses of Devon and Cornwall. By far the most important field is in the Hensbarrow granite, near St Austell. The clay is got from deep open pits (the deepest is over 91 metres (300 ft)) by hydraulic sluicing, and the impurities (mainly quartz and other minerals) are removed and dumped in the gigantic white conical spoil-heaps which form the major feature of the landscape.[3] The clay is further purified and dried, and is then sent away by rail or exported coastwise and overseas from such small ports as Fowey and Par. While much china clay and china stone still go to North Staffordshire for the pottery industry, and large quantities are exported to Europe and USA (1.75 million long tons in 1965), it is important to realise that pottery manufacture is no longer the major user of china clay. Of the home consumption, 75 per cent is in the manufacture of paper and board; it is also used in textiles, paint, pharmaceuticals, cosmetics, insecticides, as a 'hardener' in the rubber industry, and the list is extending.

*Ball-clay*[4] is another raw material for the manufacture of pottery, glazed tiles, and sanitary earthenware. The two principal sources are Eocene beds in the vicinity of Poole, in Dorset, and Oligocene lake-bed deposits near

1. *Mem. Geol. Surv., Mineral Resources*, vol. iv, HMSO, 1922.

2. Board of Trade. Working Party Reports. *China Clay*, HMSO, 1948. R. M. Barton, *History of the Cornish China-clay Industry*, Truro, 1966.

3. Between six and eight times as much waste is produced as clay, and the largest spoil-heap contains a million tons of material. Some of this sand and fine aggregate is now used for concrete-making, but little or no impression can be made by this small industry on the size or number of the spoil-heaps, which from a distance look like a gigantic encampment of white tents.

4. *Mem. Geol. Surv., Mineral Resources*, vol. xxxi, HMSO, 1929.

Bovey Tracey, in south Devonshire; in both areas there are quarries and shallow mines.

*Fireclay*[1] is a special kind of clay with properties of resistance to high temperatures; it is employed in the manufacture of refractory bricks for furnace linings, gas retorts, etc., and also for glazed sanitary pipes (the glazing of

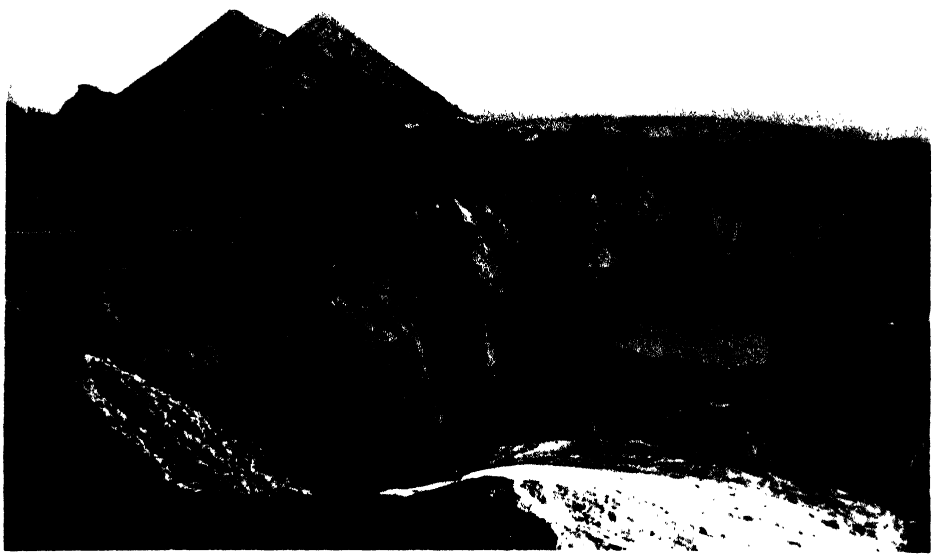


PLATE 14. Goonbarrow china-clay pit, St Austell

which needs temperatures higher than those used for ordinary brick burning). Fireclays generally occur as the seat-earths of coal seams, particularly in the Lower Coal Measures of Durham, Yorkshire, and Lancashire, in the Middle Coal Measures of the south Derbyshire coalfield (Swadlincote area), and of the Black Country, Warwickshire, and North Wales coalfields, and at the base of the Upper Coal Measures in the Potteries coalfield. In all these districts important refractory and glazed-ware industries exist; the greatest concentrations are in the Swadlincote area and in the Black Country near Stourbridge. The fireclays are generally mined, often from coal mines, but they are also sometimes quarried, as in the Swadlincote district.

1. *Mem. Geol. Surv., Mineral Resources*, vol. xiv, HMSO, 1920.

*Ganister*[1] is a rock consisting almost entirely of silica; like fireclay it occurs underneath coal seams, and is used for the manufacture of refractories. True ganister is mostly obtained in the Lower Coal Measures of the Sheffield district, but somewhat similar material, known generally as *Silica rock*, is obtained from the Millstone Grit and Lower Coal Measures of Derbyshire, Durham, and the fringes of the North and South Wales coalfields, and from the Lanarkshire coalfield.

It is fortunate that the best refractory materials—which are so much in demand by the iron and steel industry—should occur in such close proximity to some of the major centres of that industry, as in Durham, the Sheffield–Derbyshire area, South Wales, the Black Country, and central Lanarkshire.

## The commoner minerals[2]

Broadly speaking, every acre of Britain is underlain by minerals (i.e. 'rocks') of which *some* use could be made. But whether or not use *is* made depends partly on the geological circumstances, and is very largely a question of economics. Actual quarries and mines are situated where they are because the operations can be profitably conducted—the quality of the rock is satisfactory for the purpose for which it is intended, the physical setting and available technical aids permit extraction to be undertaken at reasonable cost, and the operations can take place in suitable geographical relationship to the market for the output, and connected thereto by appropriate means of transport. Naturally enough, therefore, in a highly developed country like Britain there will tend to be clay pits and gravel pits widely scattered over the country, serving local needs, but there will also be great concentrations of such pits in those areas where geological and economic circumstances are peculiarly favourable—as with the Oxford Clay brick-making industry of Peterborough, for example, and the gravel industry of west Middlesex; so also with the limestone quarrying of Buxton, and the chalk quarrying for cement on the Thames estuary.

*Igneous rocks.* Igneous rocks are less widespread in Britain than most of the sedimentary rock types, and the occurrences are almost entirely within the Highland Zone, so that any isolated outcrops in the Lowland Zone—the Leicestershire 'granites' for example—are additionally important. Igneous rocks may be divided into the very coarsely crystalline granites, which are mainly used as ornamental and monumental stones and for heavy con-

1. *Mem. Geol. Surv.*, *Mineral Resources*, vol. xi, HMSO, 1920.
2. S. H. Beaver, 'Minerals and planning', *Geog. Journ.*, **104**, 1944, 166–93; *idem*, 'Surface mineral working in relation to planning', Town Planning Institute, 1949 (*Report of Summer School at St. Andrews*); 'Land Reclamation', *Chartered Surveyor*, **92**, 1960, 669–75 (with bibliography).

structional work, and the finer grained rocks, from fine-grained granites to basalt, which are mainly quarried for road-making materials. The question of accessibility is a major factor in the quarrying of these rocks, and large areas of some of the outcrops (e.g. the Cheviot granite) are quite untouched. Of the ornamental and constructional stones the most noteworthy are certain of the granites of Devon and Cornwall, the Shap granite, and the Aberdeen and Peterhead granites. Of the granitic rocks used for road stone those of Leicestershire (Mount Sorrel, etc.) are most utilised, with others coming from North Wales (the Lleyn), Devon and Cornwall. Of the rocks of basaltic type the chief is the Whin Sill of Northumberland and Durham, and there are other noteworthy occurrences in the Clee Hills of Shropshire, the Rowley Hills of the Black Country, and at Penmaenmawr in North Wales. Metamorphic rocks are quarried for road stone in the Malvern Hills.

*Slate.* Slaty rocks occupy large areas of the Highland Zone, particularly in the Southern Uplands, the Lake District, Wales, Cornwall, Northern Ireland, and southeastern Eire; but beds with cleavage sufficiently pronounced to render the rock fissile and capable of producing roofing slates are much more narrowly confined. By far the most important area is North Wales, where Cambrian slates are worked in enormous open quarries west of the Snowdon range (the Penrhyn–Dinorwic–Nantlle area) and Ordovician slates are mined underground at Blaenau Ffestiniog. Here there was a vast industry in the nineteenth century, to supply the colossal demand of the growing industrial towns for roofing materials; several narrow-gauge railways were built to cope with the traffic, terminating at Portmadoc, Port Dinorwic, and Port Penrhyn, where coastwise vessels loaded their cargoes. The vast quarries,[1] and even vaster spoil-heaps (for 95 per cent of what is quarried is waste) have considerably altered the natural landscape. There were other slate-quarrying areas in North Wales also, and slates were obtained in the Coniston and Keswick areas of the Lake District and at Delabole in Cornwall. The competition in the twentieth century of clay (and more recently concrete) roofing tiles has all but killed the slate industry, and a considerable legacy of derelict land is left behind.

*Limestone and chalk.* Chalk is of course a form of limestone, but is generally considered as a separate mineral. There are many sources of limestone in Britain,[2] and many uses for it—building stone, road metal, smelting flux, lime-burning, cement manufacture,[3] chemical industries, and agriculture. The Carboniferous Limestone formation is by far the most important source, and the very pure limestones which occur in parts of the Pennines (particularly the High Peak district near Buxton, the Clitheroe district, and Weardale), in North Wales, in South Wales, in the Mendips, and on the

1. The Dinorwic quarries, near Llanberis, cover 283 hectares (700 acres) of the hillside, and the top level is 548 metres (1800 ft) above the bottom level. They closed in 1970.
2. F. J. North, *Limestones*, London, 1930, especially Chapters 4–12.
3. See P. N. Grimshaw, 'The U.K. Portland cement industry', *Geography*, 53, 1968, 81–4.

fringes of the Lake District are excavated in very large quarries. The Magnesian Limestone (Permian) yields building stone and *dolomite* at intervals along its outcrop from Sunderland to Nottingham. Dolomite is used for the basic linings of steel furnaces (cf. p. 376); the most important localities for this mineral are Coxhoe (Co. Durham), Conisbrough (Yorks.), and Steetley (near Worksop). At Hopton, Derbyshire, the dolomitised Carboniferous Limestone is quarried for the production of metallic magnesium. In the Jurassic series there are many fine building and facing stones, such as the Ancaster and Weldon stones of Lincolnshire, the Bath stone of the Cotswolds, and the famous Portland stone from the Isle of Portland. Some of the Jurassic limestones are also used for cement making, for example, the Lower Lias in Warwickshire (Rugby, Harbury) and the Lincolnshire Limestone at Ketton in Rutland.

The Chalk has long been used in a small way as a source of agricultural lime, but the twentieth century has witnessed an enormous expansion of chalk quarrying in certain areas to serve the cement industry, and about three-quarters of the country's cement industry is based upon chalk. The chief area comprises the banks of the lower Thames, in Essex and Kent, where huge chalk quarries are accompanied by pits in the London Clay which yield the clay necessary for mixing with the chalk, and by cement works on the river bank, using water transport for incoming coal and exported cement. On the edge of the Chilterns near Tring, Luton, and Cambridge, the Lower Chalk is sufficiently clayey to be used alone for cement making. Other areas include the lower Medway and the Humber above Hull, both with waterfront sites for the cement works.

*Brick clays.*[1] In 1939 there were more than 1250 brickworks in Great Britain, most of them served by adjacent clay-holes. Nearly one-third of them used clay and shale from the Coal Measures (sometimes obtained as a byproduct of coal mining)—partly because of the suitability of such clays, but also because the coalfields contain so many large urbanised areas where the demand for bricks is great. Nearly another one-third used the most recent clays—glacial, alluvial, brickearth, etc. The remainder mostly used Jurassic and Cretaceous clays. This simple statement, however, conceals a most important fact, namely, that over one-third of the country's brick output came, before the war, from about thirty mass-production works using Oxford Clay in the vicinity of Peterborough, Bedford, and Bletchley, in the 'Great Clay Vale'. The Oxford Clay yields a thick and reasonably homogeneous clay containing about 5 per cent of carbonaceous matter, which makes for very low fuel consumption. The clay is dug by large excavators, and the bricks are mechanically pressed into shape. The works at the new village of Stewartby, near Bedford, is the largest in the world.

1. See *Clay Brickmaking in Great Britain*, National Brick Advisory Council, Paper vi, HMSO, 1950. Also M. B. Gleave, 'Some contrasts in the English brick-making industry', *Tijds. v. Econ. en Soc. Geog.*, 1965, 54–61.

Since the war the concentration has become even more striking; over 600 brickworks have been closed and 54 per cent of the national output of bricks comes from large works in the Oxford Clay.

Roofing tiles are also mostly made from clay. Many small brickworks also make tiles, but a large proportion of the country's output is made from the Etruria Marl formation (Upper Coal Measures) in the North Staffordshire coalfield and in the Black Country. The same formation yields the famous engineering bricks known as 'Staffordshire blues'. Both these Staffordshire products are declining in the face of competition from alternative materials. Concrete tiles are replacing clay tiles, and mass concrete is used instead of blue bricks.

*Sandstones and sands.* Sandstones, of varying hardness, are used for building and constructional purposes, for road metal, for paving, for grindstones, and sometimes, as already noted, for refractories. As local building material sandstone is often evident in villages and towns, but little is quarried for this purpose now, and to an increasing extent concrete slabs and tarmacadam are replacing the paving flags which used mostly to come from the mid-Pennines of Yorkshire and Lancashire. The Millstone Grit and Coal Measures have been by far the more important sources of sandstone in the past. Red Triassic sandstones are very much in evidence in churches and large buildings all over the Midlands; the Old Red Sandstone has been much used in Scotland.

Sands, from relatively less-consolidated deposits, have many uses, of which the most important are in building (mortar, concrete, etc.), metallurgical work, and glass-making. Foundry sand for metal-casting is mostly obtained from the Trias of the west and east Midlands. Glass-sand, of exceptional purity, comes especially from the Lower Greensand of Leighton Buzzard and King's Lynn, and from a superficial deposit known as the Shirdley Hill Sands in southwest Lancashire. Sand for concrete comes almost entirely from gravel-pits.

*Gravel.*[1] The three major sources of gravel are (*a*) river-gravels, alluvial, and terrace; (*b*) glacial deposits—sheets of sand and gravel deposited as glacial outwash beyond the limits of the ice-sheets, and occasional morainic accumulations and eskers; (*c*) 'solid' deposits, of which the chief is the Bunter Pebble Beds (Triassic) of the West Midlands (mainly north and south Staffordshire). The river gravels are commonly worked in 'wet' pits, i.e. the gravel is mechanically dug or pumped from beneath the permanent water-level, so that a lake is left behind when the gravel has been extracted. The glacial gravels, more frequently occurring at higher levels, are usually worked in dry pits just like most other minerals. The deposits are very wide-

1. S. W. Wooldridge and S. H. Beaver, 'The working of sand and gravel in Britain: a problem in land use', *Geog. Journ.*, 115, 1950, 42–57. Reports of the Advisory Committee on Sand and Gravel, HMSO, 1948–53. S. H. Beaver, *The Geology of Sand and Gravel*, Sand and Gravel Association, 1968.

spread and scattered, which is fortunate since the demand for sand and gravel for building, for road-making, etc., is also spread throughout the country. Gravel mostly moves by road to its destination, and relatively little goes beyond an economic margin of about 50 kilometres (thirty miles). There is some tendency to concentrate on the broader and more profitably worked gravel spreads, particularly of river gravels, which are usually cleaner and more homogeneous than the glacial gravels, and about one-third of the country's output comes from the Thames terraces of the London area, where land use problems of considerable magnitude are created owing

PLATE 15. Wet gravel pit in the Soar valley, Leicestershire

The gravel is dug from beneath the water level by a dragline excavator. The islands in the lake are of clay or worthless gravel

to the high agricultural value of the terrace lands and the many competing uses for land within the Metropolitan region. But at least the 'Great Wen' provides abundant waste materials for filling up the lakes which gravel extraction creates – though the demand is now for the excavations to be left as lagoons for angling, sailing and water sports.

As already noted, the gravel industry has for some time been second only to coal mining in respect of output tonnage. There are about a thousand gravel pits in the country, and their annual land consumption is of the order of 1600 hectares (4000 acres), which is about two-thirds of the total land area consumed annually by quarries of all kinds.

Upwards of 10 million metric tons of sand and gravel are landed annually at various estuarine ports, the result of submarine dredging. The outer Thames estuary (off the Essex coast), the Mersey, the Severn (east of the Holms islands) and the approaches to Southampton are the major sources of this material—which of course creates no land use problems at all.

# 16
# Iron and steel

The origin of the British iron industry is lost in obscurity. The five hundred years before the Christian era, however, are known as the Iron Age, and in all probability the Celtic inhabitants of Britain were fairly expert in the working of the metal: the finding of Celtic pottery in association with iron slags in the Furness[1] district and near Northampton[2] is evidence of at least two localities in which the actual smelting was performed. That the Romans worked the iron ores of our islands is also quite certain. Sites of furnaces and heaps of slag lying near accumulations of Roman coins and pottery have been identified in Furness, in the Forest of Dean, in the Weald, in the Mendips, in Northumberland and Durham, in Northamptonshire, and in South Wales.[3] The earlier furnaces were usually situated in exposed places, where the wind would create a natural blast; later, sites were chosen along streams where a small waterwheel could be used to work the primitive bellows. After the Roman occupation there are few records and, apart from a few scattered notices in the Domesday Survey,[4] where 'ferraria' (ironworks) are occasionally mentioned, we have no positive information until the twelfth century.

The two most important medieval centres of the iron industry were the Forest of Dean and the Weald of Sussex and Kent.

*The Forest of Dean.* This was for long the chief area in the country for iron smelting.[5] As early as 1282 there were sixty forges in the forest using the local ore, and the industry continued to flourish for many centuries. In the seventeenth century the area was importing richer ore from Lancashire to supplement the local supplies and was sending iron to the Birmingham area for working up into implements and weapons.

*The Weald of Sussex and Kent.* In the sixteenth and seventeenth centuries this

1. G. M. Tweddell, *Furness Past and Present*, 1876.
2. *Victoria County History*, Northamptonshire, i, 151.
3. Kendall, *Iron Ores of Great Britain and Ireland*, Crosby, Lockwood, 1892, Chapter 2. More detailed references will be found in the volumes of the *Victoria County History*, e.g. *Cumberland*, ii, 385–406; *Durham*, ii, 278–93; *Yorkshire* ii, 341–51; *Lancashire*, ii, 360–4; *Derbyshire*, ii, 356–62; *Gloucestershire*, ii, 216–33; *Worcestershire*, ii, 267–71.
4. For example, Gloucestershire, in the Forest of Dean, and at Pucklechurch; Northamptonshire, at Gretton and Corby; Yorkshire (East Riding), at Hessle.
5. See H. G. Nicholls, *Iron Making in the Olden Times*, 1866.

area was even greater than the Forest of Dean in the importance of its iron industry. The first cast iron guns were made at Buxted in 1543, and a large proportion of the British ordnance was subsequently made in the Weald. In 1574 there were no less than thirty-two smelting furnaces and thirty-eight forges in Sussex, besides numerous others in Kent.[1]

In addition we have definite records of iron making in Northumberland and Durham from the thirteenth century onwards, in Northamptonshire and Lincolnshire in the twelfth and thirteenth centuries, in the West Riding of Yorkshire from the twelfth century, and in Rosedale (North Riding) in the fourteenth century, in Cumberland and in Derbyshire from the twelfth century, in the Furness district from the thirteenth century, and in South Wales from the fourteenth century, together with evidence of the existence and working of iron ore in certain other localities. In fact, during the medieval period, the iron industry in Britain was fairly widespread, owing to the abundance of iron ore near the surface in many parts of the country, and the ample timber supplies which could nearly always be found in the vicinity of the ore deposits. So great was the amount of charcoal necessary, however, that the forests were being rapidly depleted,[2] and in the reign of Queen Elizabeth stringent measures were passed to prevent the reckless destruction of our timber supply at a time when every log was valuable for building ships of war. Only those areas which were especially favoured by extensive forests, like the Weald and the Forest of Dean, were able to maintain their industry on a large scale; for, however rich a deposit might be, overland movement of the ore was impracticable except for short distances when pack horses were the only means of transport available. The Cumberland and Lancashire region, lacking extensive timber resources, but having a seaboard situation, continued to extract ore for export by sea to the Forest of Dean and South Wales and later to Ayrshire and the Clyde.

This distribution of the industry began to suffer a radical change in the eighteenth century owing to the substitution of coal for charcoal in the smelting process. Dud Dudley, a Staffordshire ironmaster, had patented a process of smelting iron with 'pit-cole' and 'sea-cole' as early as 1621, but neither his nor other suggested methods were successful, and owing to the failing timber supply the British iron industry suffered a steady decline for over a century.[3] By 1740, in fact, we were importing mainly from Sweden and Russia nearly twice as much iron as was made at home.

The real beginning of the modern era of iron making came with the

1. See W. Topley, *Geology of the Weald*, HMSO, 1873; also E. Straker, *Wealden Iron*, G. Bell, 1931; and M. Delany, *The Historical Geography of the Wealden Iron Industry*, Benn, 1921.
2. It is probable that 0.4 hectare (an acre) of woodland yielded only sufficient charcoal to make three metric tons of iron, and as a single furnace in the sixteenth century could make 20 metric tons a week it is obvious that the destruction of the forests must have been very rapid.
3. T. S. Ashton, *Iron and Steel in the Industrial Revolution*, 2nd edn, 1951, p. 10. This book is indispensable for a study of the iron industry in the eighteenth century.

introduction, by Abraham Darby of Coalbrookdale in Shropshire, of the use of coke in the blast furnace. Darby had probably smelted iron with coke as early as 1709, but such a revolutionary innovation as this naturally required many years of experimenting for its perfection; since so little was

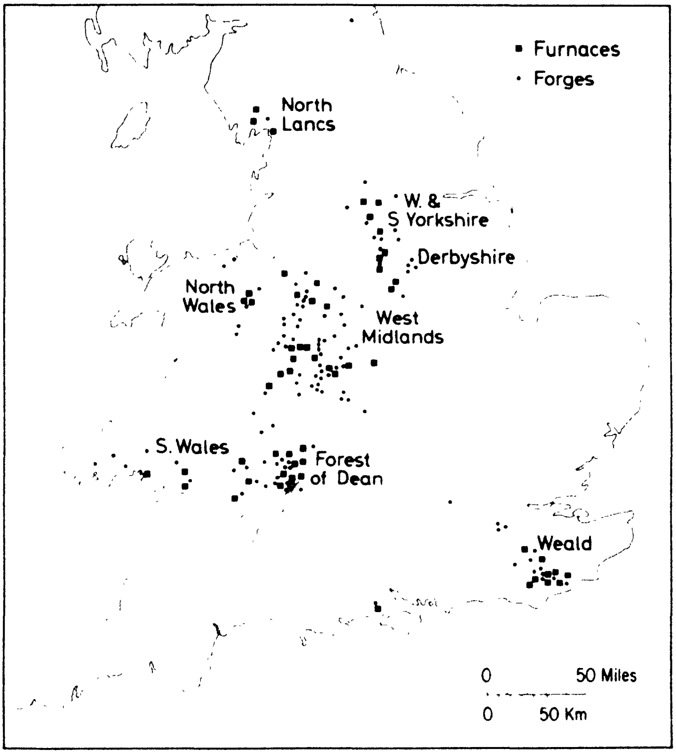



FIG. 159. The iron industry of England and Wales in 1717
(After B. L. C. Johnson, compiled from John Fuller's list.)
Compare Fig. 160 and note that Coal Measure ironstones had already localised part of the industry in and around the coalfield areas where adequate charcoal was available for the furnaces, together with suitable coals for the forges. The subsequent importance of the coalfields of Yorkshire, Derbyshire, Shropshire, North and South Staffordshire, South and North Wales was already foreshadowed half a century before the Industrial Revolution.

known of the properties of the coal and the iron ore or the chemical reactions that went on inside the furnace. Moreover, not all coals were found to be suitable for coking,[1] and the quality of the pig iron could not always be relied upon. It was not until about 1760 then that the erection of new and larger furnaces adapted for using coal and coke inaugurated a period of development and expansion in the iron industry. This development coincided with, and was to a large extent aided by, the perfection of the steam engine, which could be used for pumping water out of flooded coal mines

1. The coal used by Darby was the 'clod', which proved peculiarly suited to the process of carbonisation in large lumps in open heaps—cf. p. 333.

and for creating the more powerful blast which the use of coke in the furnace demanded. Smeaton built the first steam engine for producing blast in 1760, but it was left to James Watt to commence the construction of efficient engines on a commercial scale about 1775, and a few years later to adapt his engines to rotative motion. The consequences were profound. The steam engine needed a large amount of iron in its construction, and an increased iron production in turn necessitated the provision of more and larger engines, not only for blowing the furnaces, but also for pumping and working the winding machinery of the coal mines, which were stimulated by the demand for more coal for smelting. The increased capacity for iron production was also followed by a rapid increase in the number and variety of the uses to which the metal could be put. The first cast iron bridge was built at Ironbridge in 1779, and during the next few decades all kinds of machinery, especially textile machinery, were introduced to replace contrivances formerly made of wood or the less common metals, copper and brass.

PLATE 16. The iron bridge over the Severn at Ironbridge, erected 1779

In 1784 Henry Cort perfected the puddling furnace for making malleable or wrought iron, using coke as fuel. He also introduced the use of rollers in place of hammers in drawing out the iron into bars. These processes pro-

vided a further stimulus for the iron industry by enabling much larger outputs to be obtained in very much less time than formerly, and they helped to strengthen a movement which had been going on for twenty years, namely the increasing concentration of the ironworks on the coalfields. Progress was not rapid—in 1788 nearly half the furnaces in Britain were still using charcoal—but slowly and surely the pull of those areas which

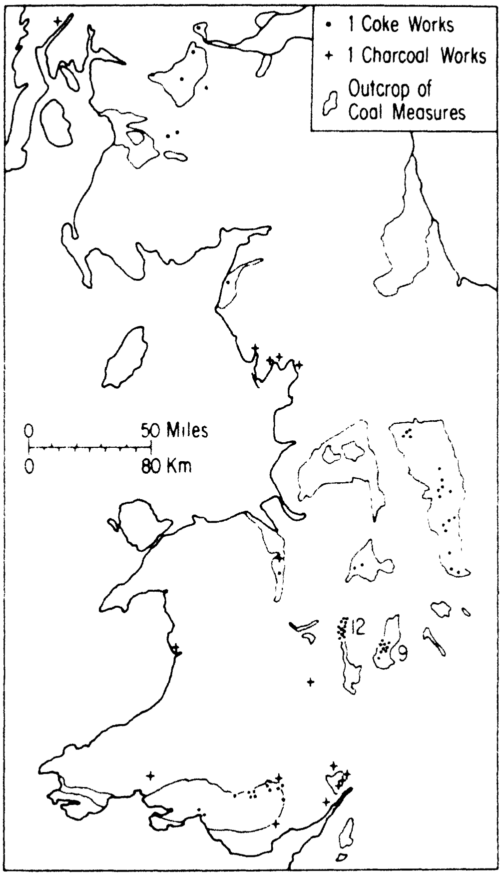



FIG. 160. Blast furnaces in 1796

Exposed coalfields outlined. The last of the Wealden furnaces, at Ashburnham, is not shown on this map. Note the absence of furnaces in south Lancashire and north-eastern England.

were favoured with abundant iron ore in the same measures as the coal seams was beginning to assert itself. By 1806 only eleven charcoal furnaces remained out of the 300 or so that existed 150 years earlier, and the clustering of the ironworks round the coalfields of South Wales, South Staffs., Salop, and Derby was very marked. The coalfields of Northumberland and Durham and South Lancashire, however, being almost devoid of Coal

Measure ironstones (see Fig. 164) and lacking coals which could be coked by the methods then available, or were suitable for using raw in the furnaces, failed to develop extensive iron industries at this time.

The iron industry also received a considerable fillip during this period from the waging of wars, which necessitated large supplies of iron weapons and ammunition. The American War of Independence occupied the years 1776–80, and between 1793 and 1815 wars were almost continuous on the continent. These wars not only stimulated our iron industry but, by ruining the greater part of Europe, placed Britain in a very strong commercial position.[1]

The first half of the nineteenth century was a period of gradual expansion and of improved technique in the iron industry.[2] Two events are important. In 1828, Neilson, a Glasgow gasworks foreman, suggested the use of hot, instead of cold, air in blowing the furnace. This process, which reduced the fuel consumption considerably, gave a remarkable fillip to the industry in Scotland, and was later taken up in England.[3] Then in the 'forties came the 'railway mania', which created an enormous demand for rails and locomotives. The first successful locomotive had been built in 1812 by Blenkinsop, and the Stockton and Darlington Railway was opened in 1825; but the years 1845–47 marked the great boom in railway development.

Throughout the period since the introduction of coke fuel the ores of iron used in Britain had been of the clayband and blackband[4] types occurring in the Carboniferous rocks, together with smaller amounts of haematite from Cumberland and Furness. In 1851 the pig iron production of Britain stood at the level of about 2.5 million metric tons (which was half the world's supply) of which the greater part (*c.* 2.1 million metric tons) came from three areas, Scotland, South Wales, and south Staffordshire. It is not surprising, therefore, to find that the Coal Measure ores, especially in the Midlands, where working had been going on continuously for over a century, were beginning to show signs of a decreasing yield due not so much to actual exhaustion as to the increased cost and difficulty of working the seams of nodules at a considerable depth. At this juncture, however, an entirely new source of ore supply was discovered[5] in the belt of Jurassic scarplands which stretches across England from the Cleveland Hills to the Dorset coast. These ores, first worked in North Yorkshire about 1850, and in Northamptonshire a year or two later, have had far-reaching effects upon

1. L. C. Knowles, *Industrial and Commercial Revolutions of the Nineteenth Century*, 1927, p. 102.
2. 1816, Rogers's improved puddling furnace; 1842, Nasmyth's steam hammer; 1845, first attempt to utilise waste blast-furnace gases for heating blast and raising steam.
3. See, with reference to this and to the matter of the preceding paragraphs, H. Scrivenor, *History of the Iron Trade*, 2nd edn, 1854.
4. Blackband was not discovered till 1801, and not extensively employed until after the introduction of the hot-blast. See D. Mushet, *Papers on Iron and Steel*, 1840.
5. Or rather rediscovered, for, as we have seen, Roman and medieval workings are known to have existed in Northamptonshire, Lincolnshire, and North Yorkshire.

the development of the British iron and steel industry, and their importance is difficult to overestimate. The commencement of iron smelting in Cleveland and Northamptonshire marked the beginning of a decline in that great attraction which had been exercised by the coalfields ever since the introduction of coal as a fuel in the process of smelting. When every ton of pig iron needed eight tons of coal to smelt it the setting up of furnaces away from the coalfields was obviously not an economic proposition. But with coal consumption reduced to two or three tons and the use of the Jurassic ores entailing an ore consumption of about the same amount, it became possible for the costs of coal and ore transport to be reduced almost to level terms, and at once the pull of the coalfields began to decrease in strength. The seaboard situation of Cleveland, together with the nearness of the Durham coalfield, now available as a source of coke through the development of the beehive coke oven, sent this area forging far ahead of the inland Northamptonshire, where coking coal was at least sixty miles away.

The second half of the nineteenth century witnessed remarkable progress in the heavy metallurgical industry of Britain, a progress which was ultimately bound up with the substitution of steel for wrought iron. Huntsman's crucible furnace, invented in 1742, had for over a century been the only efficient means of producing steel, and this was a very costly process. In 1855 only about 50 000 tons of steel were produced in Britain at a cost of £75 per ton. In 1856 Bessemer introduced his 'converter', which, making use of the heat generated by blowing a blast of air through a ladle of molten pig iron, without the employment of the large amount of fuel consumed in the crucible method, could produce much larger quantities of good steel in a much shorter time (about twenty minutes only) at much less expense. Indeed, by 1864 the price of a ton of open-hearth steel rails had been reduced to £17 10*s*.[1] Almost on the heels of Bessemer came William Siemens, who in 1861 patented the open-hearth type of regenerative gas-fired furnace for steel making. As with most revolutionary inventions, however, it took many years for the new steel processes to become firmly set, and nearly thirty years elapsed after Bessemer's invention before steel finally succeeded in supplanting wrought iron. Until the early 'eighties, in fact, the enormous demand for iron rails and iron ships was accompanied by a corresponding rapid increase in the size of the puddling industry and the number of of puddling furnaces rose from 3462 in 1860 to 7575 in 1875.[2] Moreover, except in certain cases, the steel industry was hampered by the necessity, in both the converter and open-hearth process (which employed acid, or silica, furnace linings), for fairly pure, non-phosphoric ores, such as occur in Britain only in Cumberland and North Lancashire. The bulk of British ores, including the Jurassic ironstones, were useless for steel making, and thus we find a new feature introduced into the British iron and steel industry,

1. Lowthian Bell, *The Iron Trade of the United Kingdom*, 1886, p. 20.
2. *Ibid.*

namely, the import of large quantities or rich, non-phosphoric ores from northern Spain into those steel-making areas such as Cleveland and South Wales, which were either on the coast or had easy access thereto. In 1869 scarcely 1 per cent of the ore used in Britain was imported. In 1882 this figure had risen to 18 per cent. The invention in 1879 by Messrs Thomas and Gilchrist of the 'basic process' (i.e. lining the steel furnace with a basic material such as dolomite, in order to get rid of the phosphoric impurities) might have been expected to change this state of affairs, since it permitted the use, for steel working, of the abundant phosphoric ores in the Jurassic rocks of Cleveland and the southeast Midlands. But the basic process, needing special furnace linings and entailing the payment of high royalty charges, was then more costly than the acid process; and so cheap were the rich foreign ores that it was actually less expensive, at Middlesbrough, to convert rich Bilbao ore into steel rails by the acid process than to manufacture iron rails without conversion into steel from the lean phosphoric ore of the Cleveland Hills only a few miles away.[1]

Whether acid or basic, however, the production of steel rapidly increased in the last quarter of the nineteenth century, and steel began to be used for almost every purpose to which puddled iron had previously been applied — of which the most important were for rails, ships, and in constructional engineering.[2] But while British production of iron and steel continued to expand, our position relative to the rest of the world exhibited a slow decline. Between 1850 and 1870 Britain was producing every year about one-half of the world's output of pig iron. The expansion of the industry in the United States, however, and the great development of basic steel in France and Germany, considerably reduced Britain's supremacy, and by the early 'nineties the United States and continental Europe had each exceeded the British output, and the home country produced less than one-third of the world's pig iron. By 1913 we were producing only one-eighth of the world's total (10 million out of 78 million metric tons), and the United States and Germany had both passed our production by a considerable margin.[3] The tale of the steel industry is similar. Before the introduction of the basic process Britain was easily first, but thereafter Germany (using the basic process

1. Lowthian Bell, *op. cit.*, p. 17.

2. *Note on iron and steel.* Pig iron—or cast iron—from the blast furnace is not pure. It contains carbon, and, if made from certain classes of ore, may contain sulphur and phosphorus; all these three elements are injurious and render the iron brittle. The carbon may be eliminated by stirring the molten iron in a puddling furnace; as the carbon disappears the liquid becomes pasty and is removed in lumps to be hammered or rolled. This is wrought iron, very tenacious but not hard enough for many purposes. The acid process of steel making so effectively removes the carbon that a small proportion has to be replaced by the addition of ferromanganese or Spiegeleisen, which contains some carbon. Steel may contain 0.3 to 2.2 per cent of carbon; it becomes exceedingly hard when cooled suddenly, and it is more flexible and elastic than wrought iron, although not so durable when exposed to the weather.

3. Germany, 17.0 million metric tons (16.76 million long tons); United States 31.40 million metric tons (30.97 million long tons).

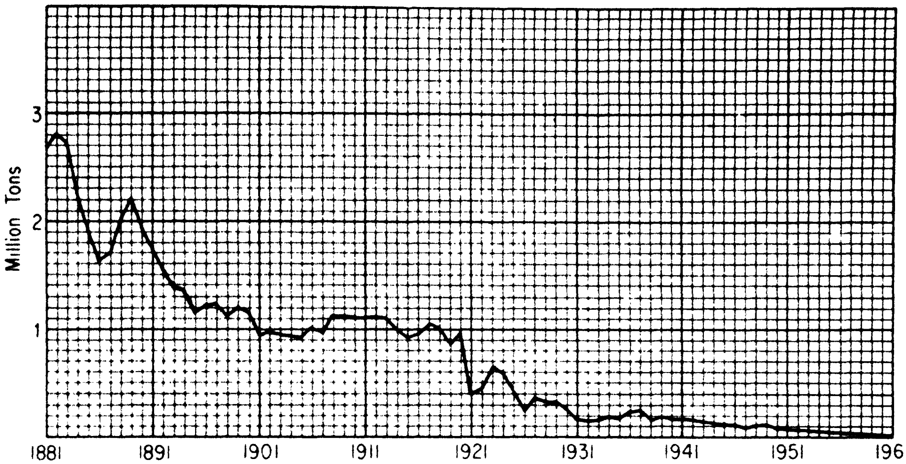



Fig. 161. Production of wrought-iron

In 1961 the total was a mere 14 000 tons

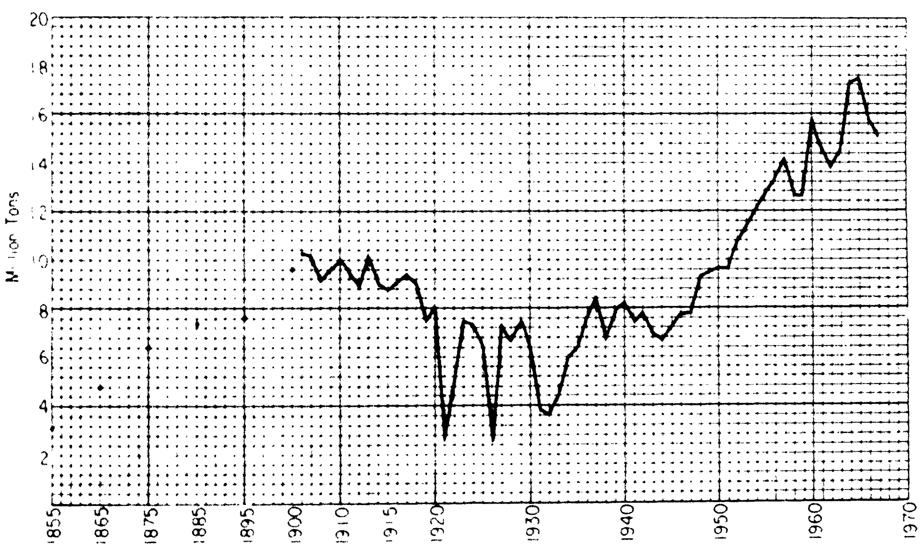



Fig. 162. Production of pig iron, 1855–1967

with Lorraine ores) and the United States (using the acid process with Lake Superior ores) began to develop rapidly, and by 1913 Britain was producing little more than one-tenth of the total world output[1] (7.7 million metric tons out of 75 million metric tons).

The period from the commencement of the supremacy of steel until the

1. See tables on pp. 113–14 of *Survey of Metal Industries*, HMSO, 1928.

First World War is characterised first by the great absolute expansion of the steel industry both at home and abroad, with the relative decline of Britain amongst the other great steel-producing nations;[1] and secondly by vast improvements in the technique of smelting and steel production, entailing a more efficient use of all apparatus and raw materials employed, and especially a considerable reduction in fuel costs. A third feature of note is the concentration on the open-hearth process at the expense of the Bessemer converter. The open-hearth furnace, although taking a longer time (some 6–12 hours) to convert pig iron into steel, permits of greater control of its contents and so the production of more carefully graded and uniform steel and, moreover, it allows the employment of scrap, a very important economic consideration.[2]

The war of 1914–18 found the British steel industry ill-adapted for prompt adjustment to the tasks which had to be performed as a result of the phenomenal demand for steel of all grades. The wartime necessity of relying more on home iron ores and less on imports led to a considerable reorganisation of certain sections of the industry, with a material increase in the output of basic steel.

The recurrent economic crises of the period 1920–33, the boom of 1920, the slump of 1921, the general strike of 1926, the boom of 1929 and the disastrous depression of 1931–33 not only took their toll of the less efficient sections of the industry (cf. the figures given under Fig. 167) but also provided the stimulus for a great amount of reconstruction and reorganisation which took place during the later 1930s and which rendered the British iron and steel industry much more capable, in 1939, of coping with a new war than it had been in 1914. Two new works of major importance, on the site of older works, came into existence—at Corby and at Ebbw Vale—and in almost every major producing district extensive reconstruction schemes were carried out, with an increasing proportion of the total output of iron and steel coming from a decreasing number of large, integrated works (i.e. works in which all the processes from coking and smelting to the rolling of finished steel products are carried out on one site).

The Second World War, like the First, resulted in a somewhat changed pattern of production, with once again increasing emphasis on the use of home-produced Jurassic ironstones, and in addition with a greatly increased proportion of alloy steel (produced especially in Sheffield).[3] The

1. See, on this and other matters, T. H. Burnham and G. O. Hoskins, *Iron and Steel in Britain, 1870–1930*, 1943.

2. On an average some 40 per cent of the raw material of the British open-hearth steel industry consists of scrap, but in individual furnaces the percentage may rise to over 80. Other important considerations are the low melting losses compared with the Bessemer converter (5 per cent, cf. 15–20 per cent), and the fact that gas for firing is often readily available from the coke ovens and blast furnaces of 'integrated' works.

3. The story of British iron and steel during the war is told statistically in the British Iron and Steel Federation's volume covering the years 1939–44. See also *Iron and Coal Trades Review*, 2 Nov., 1945, pp. 667–70, and 29 March 1946, p. 578.

postwar period, however, has not repeated the disastrous history of the 'twenties. The industry has gone from strength to strength; four major new fully integrated plants have been established, all of them involving the construction of hot-strip mills for the production of sheet steel for either tinplate or motor-car bodies. The first, at Shotton on Deeside, added blast furnaces to an existing steelworks; at Margam in South Wales, a huge new plant replaced pre-existing iron- and steelworks, whilst at Ravenscraig, near Motherwell, and at Newport, Monmouthshire, virgin sites have been developed.

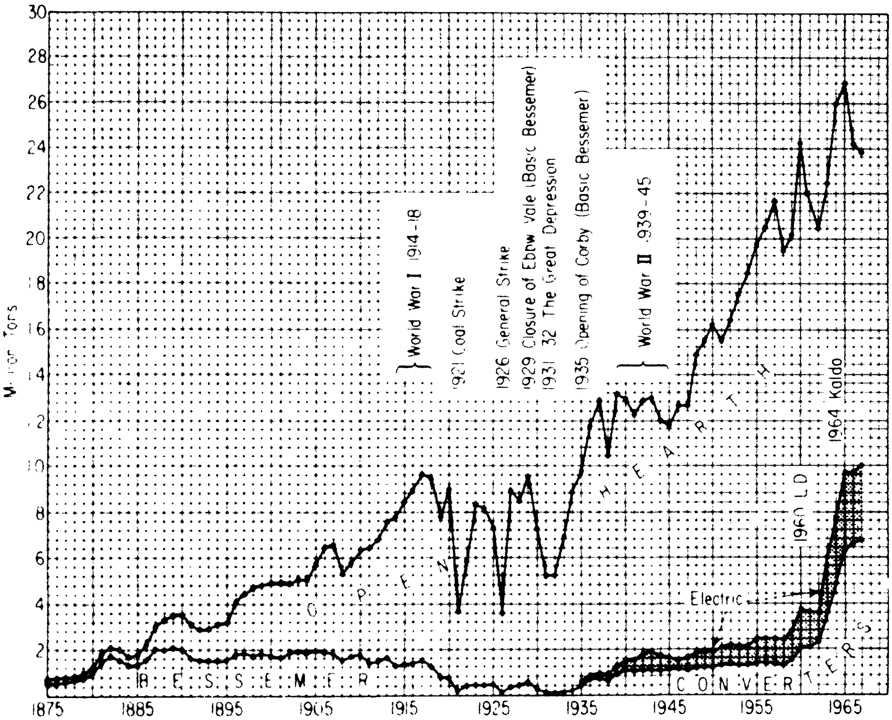



FIG. 163. Output of steel by processes, 1875–1967

Bessemer steel almost ceased in the early 1930s, from 1935 to 1959 the 'converters' section of the graph comprises the outputs of Corby, Ebbw Vale (began 1939) and Workington (acid process), from 1960 the output is greatly swelled by that of the L D and later Kaldo converters. Output of electric steel furnaces before 1935 too small to be shown on graph at this scale

Another important technical development has been the use of oxygen in place of ordinary air, in open-hearth furnaces and in new-type converters (the Kaldo and LD (Linz-Donawitz) processes). In 1961 some 11 thousand million cubic feet of oxygen were used in the iron and steel industry, of which 3.6 thousand million in open-hearths and 2.6 thousand million in converters. By 1969, however, the volume had swelled to 38 thousand million cubic feet of which 17 thousand million in converters, 7 thousand million in open-hearths, and 2 thousand million in blast furnaces. This

development, however, will have no effect on the location of the industry, for oxygen-producing plants are being set up alongside the steelworks.

## The present conditions of the industry

There are three major factors affecting the localisation of an iron and steel industry—the supply of ore, the supply of fuel, and the market for the produce.[1] One or more of these must be present or easily accessible in order to give rise to such an industry. The earliest British iron industries in the Forest of Dean and the Weald were situated where ores of iron were found in close proximity to an assured charcoal supply from the forests. Similarly, the first iron industry based on coal as a fuel became localised in Staffordshire and Salop, where both coal and iron were found in the same series of rocks. The industries of Cleveland and the Furness district of Lancashire, however, were localised upon ore-producing regions, with the nearby Durham coke and the coastal situation for the export of the produce as other favourable factors. Modern transport facilities may render possible the rise of an industry in an area devoid of both coal and iron ore—as, for example, the Ford iron works at Dagenham, on Thames-side, obtaining foreign ore and Durham coal by sea, and having its own assured market in the adjacent motor works.

### Raw materials

In order to examine the British iron and steel industry from the point of view of geographical control of development, we must first consider the raw material supplies.

*Fuel. Coal* is of course the major item, though enormous advances in fuel technology have been made during the last few decades: bigger and better blast furnaces, the sintering of ores (see below, p. 394), the use of oxygen instead of ordinary air, and of oil fuel instead of coke in open-hearth steel furnaces, have all helped to reduce the coal consumption from 3145 kilogrammes per metric ton (62.9 cwt per long ton) of steel in 1924 to 1860 kilogrammes per metric ton (37.2 cwt per long ton) in 1949 and a mere 680 kilogrammes per metric ton (13.6 cwt per long ton) in 1967. The total coal consumption by the iron and steel industry is of the order of 16.1 to 19.2 million metric tons (16 to 19 million long tons) annually, most of which is coked before use. The distribution of coking coals has already been briefly described (p. 334), and it is apparent that the actual location of coking coal

1. While a supply of limestone is normally essential to the industry (about 5 cwt of limestone flux are used for each ton of pig iron), this raw material is never a localising factor, since limestones are so readily available in most districts where either iron ore or coal are found; for example, Coal Measure ironstones were seldom far from thick Carboniferous or Magnesian Limestone deposits, and the Jurassic ironstones occur in a series, the principal members of which are frequently limestones of greater or less purity.

resources has but slight present influence on the location of iron and steel works. There is certainly no clustering of blast furnaces in south Durham, in south Yorkshire, or in eastern South Wales, and of about thirty smelting works in the country, only about half a dozen lie in close proximity to their sources of coking coal. The transport of coking coal or coke is thus a major item in the cost of production, particularly for the works situated on the Jurassic orefields.

In recent years, at first due to coal shortage, there has been a tendency to employ *oil fuel* instead of producer-gas in the firing of open-hearth steel furnaces. South Wales, with the large Llandarcy refinery in the middle of the steel-making area, has gone furthest in this direction, but Middlesbrough and Scotland have also converted many furnaces to oil firing. In 1964, 1.6 million metric tons of fuel oil were used for this purpose, one-third of it in South Wales; but in view of the increasing importance of oxygen-blown converters this was probably the peak year.

*Iron ore.* The ores of iron that occur in Britain may be grouped into four broad divisions (see table on p. 390).

1. *Haematite* ($Fe_2O_3$), including 'kidney ore'. This occurs in Cumberland and northwest Lancashire[1] in various irregular deposits in the Carboniferous Limestone which wraps round the western and southern sides of the Lake District dome. The iron is generally assumed to have been derived by solution from the red Triassic beds which formerly covered the area, and subsequent concentration in cavities in the jointed limestone—the concentration being frequently guided by faults which brought together beds of contrasted texture.

Two separate areas were important for the production of this type of ore, and the mode of occurrence in each of these is rather different. In west Cumberland, in the neighbourhood of Cleator, Egremont, and Beckermet occur numerous irregular masses of ore, sometimes disposed more or less vertically up against faults, sometimes more or less interbedded with the limestone and the sandstone and the shales which accompany it, and in other cases showing no form or structure at all. Farther south, extending on either side of the Duddon estuary from southwest Cumberland into the Furness district are a number of dishlike deposits, practically solid masses of ore occupying great hollows in the limestone. The largest of these, the famous Hodbarrow deposit, near Millom, contained originally over 8 million cubic yards of almost solid ore. In both areas the deposits are within a few hundred feet of the surface, but they are covered by thick deposits of glacial drift, which conceals the 'solid' geology and increases the difficulty of locating and working the ores.

The two areas were formerly of equal importance as ore raisers, but the

1. *Mem. Geol. Survey, Mineral Resources*. vol. viii, *Haematites of West Cumberland, Lancashire, and the Lake District*, 2nd edn, 1924. See also T. H. Bainbridge, 'Iron ore mining in Cumbria', *Geography*, **19**, 1934, 274–87. Also *Geology of the Iron-Ore field of South Cumberland and Furness*, Geol. Surv. Wartime Pamphlet no. 16, 1941.

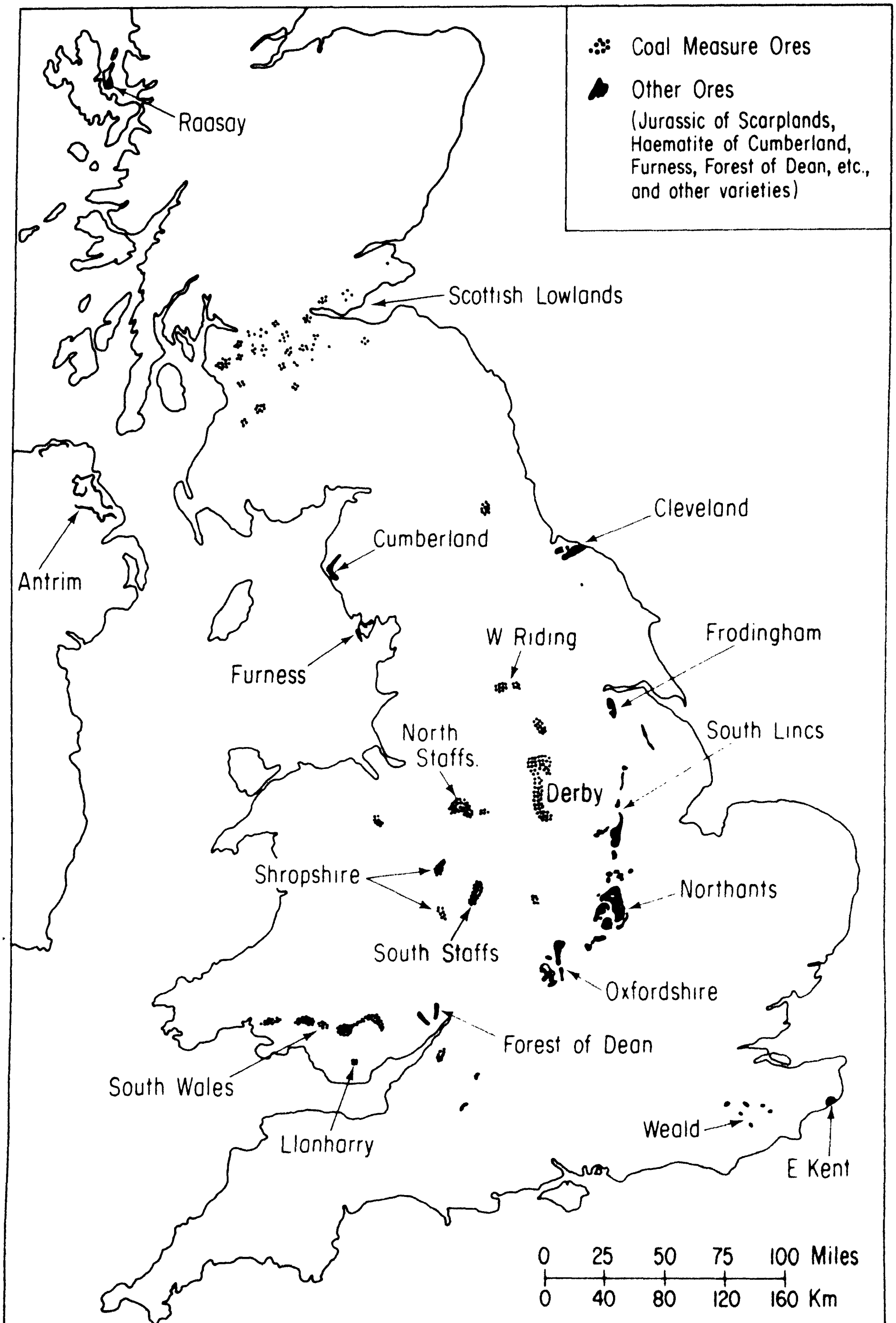



FIG. 164. The iron ores of Britain

The only ones of present importance are the Jurassic ores of Cleveland, Frodingham, South Lincs and Northants, with the Haematites of Cumberland and Llanharry.

greater ease of working the Furness deposits has led to their extinction more rapidly than is the case with the irregular veins and masses of western Cumberland, and whereas in the early 'eighties (the period of greatest production) each area was producing about 1.5 million tons per annum, the Furness area has now ceased to produce, whilst Cumberland has an output of only 0.15 million metric tons (see table on p. 390). Only two mines remain, near Egremont. This haematite is the richest ore produced in Britain, having an iron content of nearly 50 per cent. It is also important as being non-phosphoric.

The modern development of these ores dates from about 1825, and a great fillip was given to their extraction and export by the completion of the Furness Railway in 1846, and of the Whitehaven, Cleator and Egremont line in 1857;[1] whilst the completion of the Stainmore Pass line across the Pennines in 1861 opened up a new route to the Durham coalfield and Middlesbrough.

2. *The bedded ores occurring in the Coal Measures.*[2] These ores are of great historical interest since they were the foundation upon which British supremacy in the iron industry was built up during the hundred years 1750 to 1850. At the end of this period they still accounted for nine-tenths of the entire British output of ore, and production continued to increase in certain areas until the 'seventies. Since then the output has rapidly declined both relatively and absolutely, and none at all has been raised since the Second World War. There were two distinct varieties of ore found in the Coal Measures, 'clayband' and 'blackband'. Clayband ironstone consists of carbonate of iron mechanically mingled with earthy matter. It usually takes the form of thin seams, either continuous or nodular, varying from a few centimetres to several metres in thickness, interbedded with shales or less frequently with sandstones. It is noteworthy that the clayband ores are not evenly distributed throughout the Coal Measures, either stratigraphically or in area. The areas over which they were formerly of greatest importance are South Staffordshire, Shropshire, South Wales, Derbyshire, the West Riding of Yorkshire, and the Scottish Lowlands.[3] The blackband ores are carbonaceous ironstones, i.e. they contain coaly matter sufficient for calcining the ore without the addition of coal. They occur in even closer association with coal than the claybands. They are usually found on the top of coal seams and in Scotland some blackbands are actually found to pass laterally into coal. On the other hand, they usually occur in thinner seams than the claybands. Their value as ores of iron was not realised until 1801,

1. In the late 1850s close on 304 000 metric tons (300 000 long tons) of ore were being exported annually mostly to South Wales.

2. *Mem. Geol. Survey, Mineral Resources*, vol. xiii, *Pre-Carboniferous and Carboniferous bedded ores of England and Wales*, 1920; also vol. xi, *Iron Ores of Scotland*, 1920.

3. It should be noted that iron ores, as well as coal, occur in the Carboniferous Limestone and Millstone Grit formations of Scotland, in addition to their development in the true Coal Measures.

and it was some time before they were extensively used in the iron industry. The only two coalfield areas in which they were discovered to be developed in quantity were North Staffordshire and Scotland. In Scotland they were especially valuable since they showed such an adaptability to the use of the hot blast, a far greater reduction in fuel consumption being obtained when using blackband ores and the Scottish 'splint' coal than with any other combination of ore and fuel. In contrast with the haematite, the clayband and blackband ores are lean, containing only about 30 per cent of metallic iron.

The decline in the output of Coal Measure ironstone was due to two main causes. In the first place there is the actual exhaustion of many of the best seams, especially in those areas like Shropshire and south Staffordshire, which were earliest worked. But the ores are by no means wholly exhausted. According to an estimate made in 1922 there were 'actual' reserves of over 1000 million metric tons, and a further 'probable' reserve of 1200 million metric tons. The second reason is thus the increasing difficulty and cost of working such thin seams of lean ore at depth (for an enormous amount of 'waste' material has to be removed and brought to the surface before the bands and nodules of ore can be extracted). This cost was rendered prohibitive by the cheapness with which equally good Jurassic ores, quarried or mined in thick bands at small depth, could be obtained.[1] This huge reserve will never be mined under present or foreseeable economic conditions, and in consequence the Coal Measure ores can no longer be said to exert any influence whatsoever over the distribution of the iron and steel industry.

3. *The bedded ores of the Jurassic rocks.*[2] Although certain of these ores, as in Northamptonshire and Lincolnshire, were worked in Roman and medieval times, their value as ores of iron seems to have been completely forgotten for several centuries,[3] and they were hailed as new discoveries about 1850. Since that date they have steadily increased in importance, until at the present time their output represents over 98 per cent of the total ore raised in the British Isles. The ores occur at several different horizons in the Jurassic sequence. Several characteristics are common to them all and serve to distinguish them in a very marked way from the ores which we have previously considered. They are all lean ores, varying in their iron content from 20 to about 33 per cent; they all occur in thick beds, generally about 3 metres (10 ft) thick, but ranging from a metre or two to over 9 metres (30 ft), and in common with the whole Jurassic series they are tilted gently to the east or southeast without being greatly disturbed by folding or fault-

1. The average selling price of Coal Measure ironstone between 1925 and 1931 was just over 13*s* per ton; the figure for the equally rich Northamptonshire stone was little more than 3*s*.
2. *Mem. Geol. Survey, The Northampton Sand Ironstone: stratigraphy, structure and reserves*, HMSO, 1951; *The Liassic Ironstones*, HMSO, 1952.
3. One John Morton, writing in 1712, actually denies the existence of iron ore in Northamptonshire (*Natural History of Northamptonshire*, p. 549).

ing. Furthermore, they are all either quite close to the surface so that they can be quarried, or are easily accessible by shallow mining. In all of them the iron is in the chemical form of chamosite (a silicate of iron) or siderite (carbonate of iron), and is an original constituent of the rock, though in most cases subsequent enrichment and oxidation have occurred through the action of atmospheric waters. It is worthy of note that the 'minette' ores of Lorraine are of precisely the same character and occur on almost the same stratigraphical horizon as the Northampton Sands ores. Four important deposits may be distinguished.

(*a*) In north Lincolnshire, in the neighbourhood of Frodingham and Scunthorpe, certain beds in the Lower Lias formation are ferruginous. This is the thickest of the Jurassic ironstones, between 6 and 9 metres (20 and 30 ft) being worked, and almost all the work is opencast, for, although the thickness of overburden may amount to over 15 metres (50 ft), it consists of soft clays and shales which can be removed mechanically. The ore is, however, very lean, averaging only 20–22 per cent of iron; moreover, it contains up to 25 per cent of lime and an appreciable quantity of manganese—both qualities which influence the technique of its utilisation. The Frodingham ore was first worked in 1859; the field now produces just over one third of the total British output.

(*b*) The 'Marlstone' bed of the Middle Lias yields iron in two quite distinct areas, the Cleveland Hills of Yorkshire and the scarplands from Lincolnshire to Oxfordshire. The marlstone is not always an iron ore. Between north Yorkshire and south Lincolnshire it is barren; a gap separates the south Lincolnshire field from the Leicestershire field, and this again is separated by a barren area from the Banbury ore-bearing district. In north Yorkshire the marlstone crops out on the northern flanks of the Cleveland Hills, dipping gently southeastwards. Owing to the resistant nature of the overlying beds which form the Hills the ore bed quickly disappears underground. It was first quarried in the outliers of Eston and Upleatham only a few miles from the Tees estuary. Almost at once adit mining (i.e. tunnels driven into the hillside) became necessary, and subsequently vertical shafts were sunk to depths of as much as 213 metres (700 ft). The ore bed deteriorates southeastwards and becomes divided by shale partings which quickly reduce its thickness from the 3 metres (10 ft) which was worked on the northwestern edge of the field. The total amount of ore which has been removed from this field is about 355 million metric tons (350 million long tons). Production declined from 6 million metric tons in 1913 to under 2 million metric tons in the years 1931–36, and about 1 million metric tons in 1949–1952; and the last mine closed in 1964.

The other marlstone areas are all worked opencast. The iron in these ores is the result of concentration due to the atmospheric weathering of lean ferruginous mudstones, and consequently, as soon as the bed disappears beneath the cover of newer deposits, where it has been protected from such weathering, the iron content diminishes so rapidly as to render the rock

useless as an ore.[1] Consequently mining will probably never be necessary. The three separate fields are: (1) the Caythorpe district of south Lincolnshire (the smallest); (2) the Melton Mowbray ironstone ridge, around Holwell and Eaton in Leicestershire;[2] (3) the Banbury district on the borders of Oxfordshire and Northamptonshire (formerly the most important, but extinct since 1967). In each of these areas the ore bed varies from about 1.8 to 3.6 metres (6 to 12 ft) in thickness, but often much has been lost through denudation.

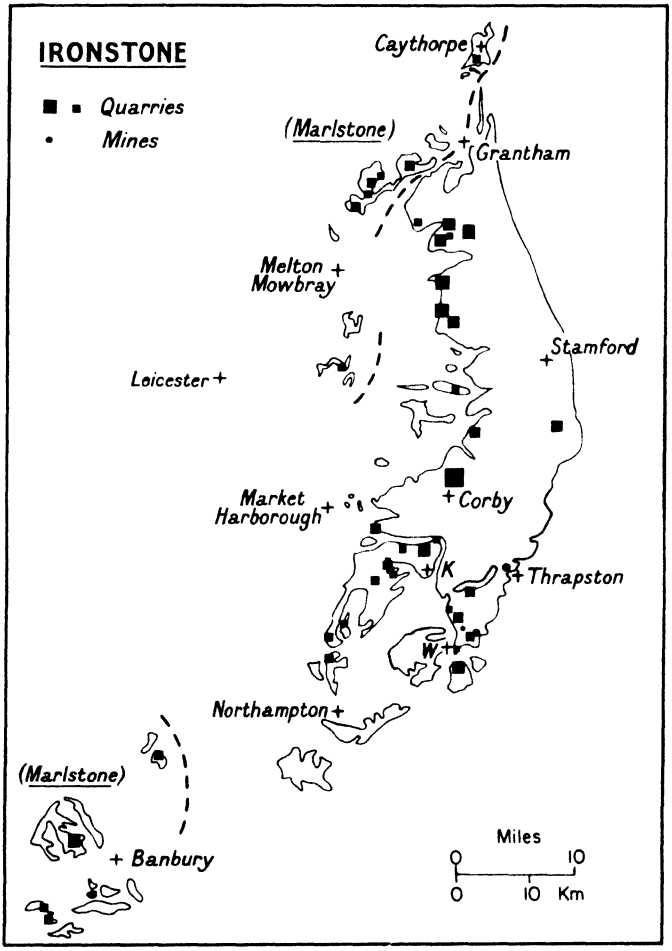



FIG. 165. The Jurassic ironstone fields of the East Midlands
This map represents the situation in the 1950s; since then, the number of individual quarries in central Northamptonshire has been much reduced, without however any reduction in output; the marlstone of Leicestershire has much declined, whilst the Banbury district is completely extinct.

1. *The Liassic Ironstones*, pp. 95, 144.
2. P. T. Wheeler, 'Ironstone working between Melton Mowbray and Grantham'. *East Midland Geog.*, 4, 1967, 239–50.

All the marlstone districts produce lean ores. The Cleveland ore contains on the average about 28 per cent of iron, and the quarried ores of the scarplands about 25 per cent.

(*c*) That portion of the Inferior Oolite formation in Northamptonshire, Rutland, and south Lincolnshire, known as the 'Northampton Sands', is, and will continue to be, one of the vital factors in the British iron and steel industry.[1] It contains a bed of iron ore, generally between 1.8 to 3.6 metres (6 and 12 ft) in thickness, which is not only the richest of the Jurassic ores (iron content 30–33 per cent) but also offers the most extensive reserve of ore of any of these fields. At the 1949–51 rate of production, about 7 million metric tons a year, the ore was estimated to last for at least 175 years.[2] The field stretches, with slight interruptions due to deterioration and denudation, from Lincoln to Towcester and, unlike the marlstone of the neighbouring areas, the ore does not deteriorate eastwards under cover. The ore is obtained by opencast methods, at depths of up to 24 to 30 metres (80 to 100 ft). It is siliceous, which makes it very suitable for foundry iron, and it is also higher in phosphorus than the other Jurassic ores, which makes the pig iron produced from it suitable for the basic Bessemer process.[3]

In all the Jurassic ore fields, except Cleveland, the railway facilities have had a great bearing upon the working of the ore, and as the vales at the foot of the Marlstone and Inferior Oolite scarps provided excellent railway routes very little additional mineral line construction has been necessary.[4] In Cleveland the more dissected nature of the country led to the building of several special mineral lines and connections with the existing tortuous branches of the North Eastern Railway (see Fig. 182).

Again, except for Middlesbrough, Scunthorpe, and more recently Corby, the working of the Jurassic ore fields has not given rise to any marked change in the distribution of population. The reason is to be found in (*a*) the scattered nature of the quarries, and (*b*) the geological conditions which permit the use of mechanical appliances and consequently a small manpower. The use of mechanical excavators, however, mainly since the First World War, greatly exaggerated the effect of ironstone quarrying on the landscape, for whereas in the days of hand working all the overburden and top soil were replaced and the land restored to agriculture, the mechanical

1. S. H. Beaver, 'The iron industry of Northamptonshire, Rutland and south Lincolnshire', *Geography*, **18**, 1933, 102–17.

2. *Mem. Geol. Surv.*, *The Northampton Sand Ironstone*, p. 7.

3. Iron containing at least 1.8 per cent of phosphorus is necessary for the basic Bessemer process. Most iron ores at present available in Britain contain too much phosphorus for the acid process and too little for basic Bessemer—one reason for the popularity of basic open-hearth. The Corby works, however, having revived the basic Bessemer process in 1935, ceased to use it in 1965, greater economies being obtainable by the use of the L-D oxygen-converter (cf. p. 379).

4. The most important mineral line is the Stainby and High Dyke branch, south of Grantham, which carries Northampton Sands ore from south Lincolnshire, on its way to Scunthorpe and Derbyshire.

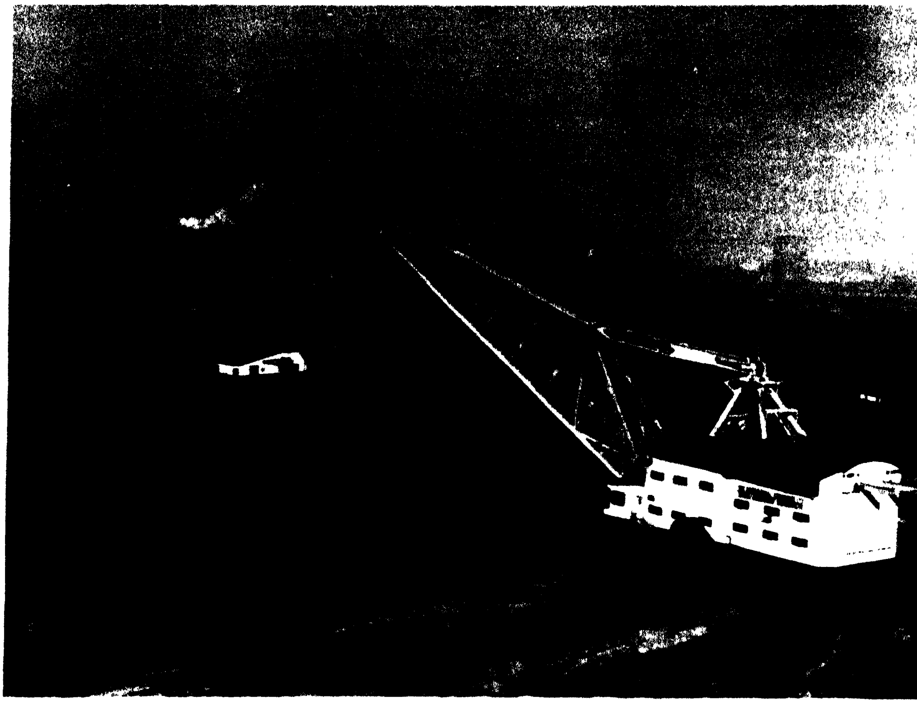


PLATE 17. Opencast iron ore mining at Scunthorpe

Large walking dragline removing overburden, which is being re-distributed by a smaller dragline and then flattened by bulldozers. A face-shovel digs ironstone on the extreme right. Steelworks in distance, with gasholders to store surplus gas from blast furnaces and coke ovens.

shovel and dragline create large dumps of overburden in 'hill and dale' formation, and the problems of afforestation and agricultural reinstatement are considerable.[1] Nevertheless, as in the case of opencast coal mining, all worked areas are now regularly restored to farming or else planted with trees.

4. *Miscellaneous ore deposits.* Although of very small importance at the present time (since they provide less than 1 per cent of the total output), certain other occurrences of iron ore have been important at various periods in the past and deserve passing notice.

In the Carboniferous Limestone of the Forest of Dean limonite (oxidised haematite $Fe_2O_3 + 3H_2O$), occurring in the same irregular fashion as the Cumberland haematites, was mined from Roman times, and it gave rise to

1. See, for example, W. D. Evans, 'The open-cast mining of ironstone and coal', *Geogrl J.* **104**, 1944, 102–19; also S. H. Beaver, *The Land of Britain, Part 58, Northamptonshire*, pp. 372–4. On restoration problems see S. H. Beaver, 'Land reclamation after surface mineral working'. *J. Tn Planning Inst.*, **41**, 1955, 146–54.

PLATE 18. Opencast iron ore mine at Cottesmore, Rutland
Dragline removes overburden, dumps it without forming 'hill and dale', and subsequently replaces the soil, agricultural restoration is complete

an extensive iron industry during the charcoal smelting period. Production declined rapidly after 1880. A similar deposit in the same formation at Llanharry (Glamorgan) is the only one of the 'other occurrences' which is still worked to any extent;[1] it supplements the imports of foreign ore at Cardiff and Port Talbot. The ore in the Upper Lias of Raasay, Scotland, was worked for a time, especially during the First World War, but its remoteness and low iron content (25 per cent) rendered the cost prohibitive. The deposit of magnetic ore occurring in the Inferior Oolite of Rosedale, Yorks, has long since been worked out. The Corallian beds of Westbury (Wilts.) contain an iron ore which formerly fed the furnace there. The concealed Corallian rocks of the East Kent coalfield have also been found to contain similar ore. Certain bodies of bedded ore occurring in the Cretaceous rocks have also been of importance in the past. Most noticeable, of course, are the ironstones in the Wealden rocks of Sussex and Kent, which were for so long the chief sources of British iron. Deposits in the Lower Cretaceous near Claxby (Lincs.) are mined by a Scunthorpe firm, and at Seend (Wilts.) is a similar small deposit which for a short time fed a small ironworks.

1. *Mem. Geol. Surv.*, *Iron Ores*, vol. x, *The Haematites of the Forest of Dean and South Wales*, 1919.

*Iron ore production* (thousand long tons)

| FORMATION | 1913 | 1931 | 1937 | 1942[2] | 1950 | 1956 | 1960 | 1964 | 1969 | AVERAGE IRON CONTENT PER CENT |
|---|---|---|---|---|---|---|---|---|---|---|
| HAEMATITE: | | | | | | | | | | |
| Cumberland | 1 361 | 613 | 737 | 594 | 342 | 323 | 315 | 274 | 143 | 48 |
| Lancashire | 406 | 96 | 120 | 21 | — | — | — | — | — | (54) |
| Total | 1 767 | 709 | 857 | 615 | 342 | 323 | 315 | 274 | 143 | |
| JURASSIC: | | | | | | | | | | |
| Lower Lias | * | 1 423 | 3 047 | 3 672 | 3 155 | 4 485 | 5 411 | 5 441 | 4 408 | 20 |
| Middle Lias, Cleveland | 5 941 | 1 497 | 2 037 | 1 884 | 1 019 | 581 | 463 | — | — | 28 |
| Middle Lias, other areas | * | 1 056 | 2 001 | 2 702 | 1 538 | 2 879 | 2 121 | 1 590 | 232 | 24 |
| Inferior Oolite | * | 2 851 | 5 834 | 10 635 | 6 804 | 7 847 | 8 657 | 8 868 | 7 185 | 31 |
| Total | 12 572 | 6 827 | 12 919 | 18 894 | 12 517 | 15 793 | 16 652 | 15 899 | 11 825 | |
| COAL MEASURES: | | | | | | | | | | |
| N. and S. Staffs. | * | 50 | 149 | 150 | — | — | — | — | — | — |
| Scotland | 591 | 8 | 22 | 36 | — | — | — | — | — | — |
| Other areas | * | 5 | 7 | 1 | — | — | — | — | — | — |
| Total | 1 542 | 73 | 178 | 187 | — | — | — | — | — | (32) |
| Other occurrences | 116[1] | 17 | 260 | 209 | 103 | 129 | 120 | 153 | 136 | 50[3] |
| Total | 15 997[1] | 7 626 | 14 215 | 19 906 | 12 963 | 16 245 | 17 087 | 16 326 | 12 103 | |
| Total (metric tons) | 16 254 | 7 748 | 14 443 | 20 225 | 13 171 | 16 506 | 17 361 | 16 588 | 12 298 | |

* Not available, as figures given by counties only, not by formations.

[1] Includes 60 000 tons from Antrim, Ireland

[2] War peak year.

[3] This figure is for the Llanharry haematite.

## Import and internal movement of iron ore

Despite the extensive reorganisation of the British iron and steel industry which was conducted during 1914–18, when our capacity for producing basic steel from the home Jurassic ores was considerably enhanced, and despite the great expansion of the Jurassic ore output, our imports of rich foreign ores have not proportionately diminished. Indeed, they have materially increased. But the reasons for importing ore are now rather different from those which influenced the first importation in the 'seventies. It was then that the demand for steel made by the acid processes became so great that Cumberland and Furness, even though their output rose to over 3 million metric tons yearly, could not supply sufficient non-phosphoric ore to feed the furnaces. By 1900 the amount imported had risen to 30 per cent of the total quantity used. Our earliest imports came almost entirely from Spain, which possessed, in the province of Vizcaya, huge reserves of rich haematite ore, non-phosphoric and yielding 50–60 per cent of iron. During the 1880s, in fact, the greater part of the shipment from Bilbao, amounting to between 3 and 4 million metric tons per annum, was destined for British ports. Swedish ores, though very rich in iron (mostly 60–70 per cent) are mostly phosphoric, and this fact, combined with the lack of transport facilities, prevented any considerable import thereof before the discovery of the basic process. The first Swedish ores to arrive in this country came from central Sweden (the Grängesberg and Dannemora areas). The colossal magnetic deposits of northern Sweden at Gällivare and Kirunavare were not available until railways were built to the coasts. Lulea began to ship ore in 1887, and the Norwegian port of Narvik began exporting Swedish ore in 1903. After 1900, too, considerable quantities of rich low-phosphorus ore were received from French and Spanish territories in North Africa, where there are extensive deposits of ore yielding over 50 per cent of iron.

In recent years between 16 and 18 million metric tons of ore have been imported into Britain annually, and there have been radical changes in the sources of supply. Since the Second World War Sweden has more than regained the dominant position that it held before the war, but North African imports have declined considerably within the last decade, while Spain has fallen—largely owing to the exhaustion of its best deposits—to a minor place. For a time Newfoundland came into the picture again with its oolitic haematites from Wabana, but these mines closed in 1966 and the large quantities of Canadian ore now imported come from the pre-Cambrian deposits on the Quebec–Labrador border that were opened up in the mid-1950s. The greatest changes, however, have been concerned with the opening up of new orefields in the pre-Cambrian rocks of West Africa and South America, and with alterations in the nature of the shipping that carries the ores. Of the West African sources Sierra Leone was first in the field; a Scottish steel company was largely responsible for this development in 1933. Lateritic ore from Conakry, in Guinea, began to

arrive in 1953, but both these sources have been far surpassed by the magnetite of the Bomi Hills in Liberia and still more recently (since 1963) the haematite from Mauritania. South American ores come from the Itabira region of Brazil, and from Venezuela. Another source, since 1965, is the USSR; and imports have even been received from as far afield as India and northwestern Australia.

*Iron ore imports* (thousand long tons)

| COUNTRY | 1913 | 1931 | 1937 | 1943[4] | 1950 | 1960 | 1965 | 1969 | AVERAGE IRON CONTENT PER CENT |
|---|---|---|---|---|---|---|---|---|---|
| Canada[1] | 100 | 27 | 258 | 3 | 123 | 3 307 | 3 018 | 2 895 | 54 |
| Sierra Leone | — | — | 337 | 502 | 733 | 738 | 547 | 372 | 61 |
| France | 327 | 77 | 408 | — | 373 | 537 | 109 | 26 | 41 |
| North Africa[2] | 1 038 | 582 | 2 350 | 848 | 2 666 | 3 662 | 1 533 | 437 | 51 |
| Spain | 4 525 | 888 | 930 | 265 | 750 | 743 | 581 | 571 | 50 |
| Sweden[3] | 854 | 446 | 2 387 | | 3 443 | 5 101 | 6 777 | 3 509 | 61 |
| Venezuela | — | — | — | | | 1 620 | 1 706 | 1 529 | 60 |
| Brazil | — | — | 38 | 262 | | 626 | 613 | 1 021 | 68 |
| Liberia | — | | — | — | | 533 | 1 531 | 1 503 | 65 |
| Guinea | — | — | — | | | 381 | 190 | | 47 |
| Other Countries | 386 | 88 | 242 | 14 | | 735 | 2 252 | 6 314[5] | |
| Total (long tons) | 7 230 | 2 108 | 6 950 | 1 894 | 8 402 | 17 969 | 18 857 | 18 177 | 57 |
| Total (metric tons) | 7 346 | 2 142 | 7 061 | 1 924 | 8 537 | 18 257 | 19 160 | 18 468 | |

[1] Newfoundland only before 1956; includes Labrador thereafter, Newfoundland ceased 1966
[2] Morocco, Algeria and Tunisia.
[3] Includes some from Norway, e.g. 652 th long tons in 1937, 715 th long tons in 1965.
[4] Lowest war year French and Scandinavian sources enemy-controlled.
[5] Includes Norway 2065, Mauritania 1957, USSR 1357 (each averaging 62–63 per cent iron).

The reasons for such large imports, and from such distant sources, are (*a*) the fact that the imported ores are in general about twice as rich as the home-produced Jurassic ores, and may be even richer if they have been concentrated or pelletised before shipment;[1] (*b*) the lower fuel consumption per ton of pig iron which the smelting of richer ores entails;[2] and (*c*) the relative cheapness of transporting iron ore in large bulk carriers of up to

1. Of the 15.1 million metric tons (15 million long tons) imported in 1967, 6.5 million metric tons were in the form of concentrates or pellets.
2. In 1967 Jurassic ores needed about 750 kilograms of coke per metric ton (15 cwt of coke per long ton) of pig iron, imported ores only 650 kilograms per metric ton (13 cwt per long ton).

60 000 tons or more, instead of in tramp ships of 10 000 tons or less. The repercussions of this last factor are considerable, for our normal ore-importing ports were incapable of accommodating such large vessels. Thus Middlesbrough has had to develop a new deepwater ore terminal; at Port Talbot the entire port has been reconstructed to take ore-carriers of up to 100 000 dwt.[1] and an entirely new ore terminal to serve the Scottish industry is proposed at Hunterston on the Ayrshire coast. Clearly the coastal or near-coastal location of much of the British iron-smelting industry—a feature which was essentially the product of the importation of foreign ore—is likely to be even more strongly emphasised in the future.

The iron ore imports are by no means evenly distributed amongst the various iron-smelting districts, for clearly the Jurassic orefield smelters (Corby, Scunthorpe) are dependent upon their local ores whilst the remaining Midland plants (Staffordshire, Derbyshire) also use home ores. South Wales (Port Talbot, Cardiff and Newport) is by far the largest importer, taking some 40 per cent of the total; it is followed by the north-eastern ports (especially Middlesbrough), east coast ports (including London and Grimsby), the Clyde, the Mersey and Workington.

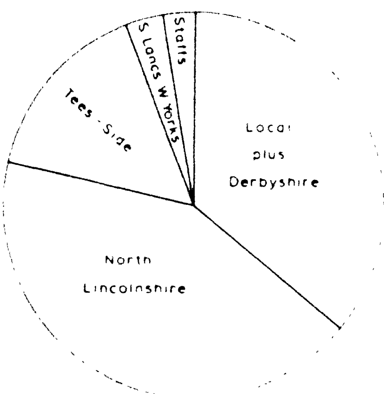



FIG. 166. Diagram showing destination of Northampton Sands iron ore in 1967

An extensive system of internal ore transport also exists in Britain, and it has an interesting geographical background. We have already seen that the presence of iron ores and coal in the same measures gave rise to iron industries in Staffordshire, Yorkshire (West Riding), Derbyshire, and South Wales. The cessation of the supply of Coal Measure ores, however, left these

1. When Australian ore first arrived at Port Talbot it was transhipped at Rotterdam from bulk carriers into smaller vessels capable of entering the port. The Russian ore could be imported at Port Talbot because it came in vessels of 10 000 tons which were the largest that Murmansk, the port of origin, could accommodate.

areas without their local raw material, which must in consequence be drawn from farther afield. The Jurassic scarplands, on the other hand, have huge ore supplies and no coal. Consequently, although furnaces exist in Northamptonshire and at Scunthorpe, a large proportion of the Jurassic ore is 'exported' to these old-established regions. Most of the Frodingham ore is used in the local furnaces, but a considerable proportion of the Marlstone and Northampton Sands ores goes into the furnaces of the Midlands. An interesting transference of ore also takes place as a result of the calcareous nature of the Frodingham ore, which is so limy that it cannot be used alone in the furnace, but requires a siliceous complement—which is supplied by the ore from the Northampton Sands of Lincolnshire and Northamptonshire.[1] The cessation of the Cleveland production is further reflected in the large amount of Northamptonshire and Rutland ore which is sent to the Tees-side furnaces. As a comment upon the facts enunciated above, Fig. 166 shows the destination of the Northampton Sands ore.

## Sinter

To an increasing extent the home output of Jurassic ores, and also some of the imported ores, are being subjected to a sintering or agglomerating process before being charged into the blast furnace. This enables the finely fragmented ores to be more effectively smelted, and with reduced fuel consumption. The crushed ores are mixed with small quantities of coke breeze and passed through a furnace, coming out in hard clinkery lumps. About 11 million metric tons of home ores and 11 million metric tons of foreign ores are now treated annually in this way, resulting in a marked increase in the efficiency of the blast furnaces.

## Other raw materials

Other raw materials of vital importance to the iron and steel industry apart from air and water[2]—include limestone, dolomite, refractories, manganese ore, alloying metals, and of course scrap. The first three of these have been briefly dealt with in Chapter 15; suffice it to say that Britain is well supplied with high-quality deposits, which are often most fortunately placed with respect to the iron and steel industries. *Manganese ore* is employed, to the extent of nearly 50 kilograms per metric ton (1 cwt per long ton) of pig iron, mainly to neutralise the harmful effects of sulphur, and so is especially used in blast furnaces producing pig iron for basic steel manu-

1. Cf. the interchange, in Lorraine, of the limy ores of the Briey plateau and the siliceous ores of the Longwy and Nancy regions.
2. Air is paradoxically the heaviest raw material of all, for anything from 3 to 7 metric *tons* of air may be used in a blast furnace to produce a ton of pig-iron, and a large furnace may use a ton of air per minute! Fortunately air is free and ubiquitous.

facture.[1] In the form of ferromanganese (which is produced in blast furnaces just like pig iron) it is used in steel melting as a de-oxidiser, especially in the Bessemer process, and it is also a constituent of high-manganese steel, which has exceptional qualities of toughness and resistance to wear. Of the alloying metals, *nickel*, used in stainless steel and for engineering purposes, *cobalt*, used in magnets and heat-resisting steels, *tungsten*, for high-speed tool steel, *molybdenum*, for high-speed and corrosion-resisting steels, and *chromium*, for tools, magnets, ball-bearings, and stainless steels, are the most important. All have to be imported.[2] Over 1.5 million metric tons of alloy steels are produced every year—nearly 60 per cent of it in Sheffield (see p. 414) and much of the rest in Scotland, in south Lancashire, in South Wales and in the Midlands.

### Scrap

In recent years some 17 to 20 million metric tons of scrap have been used annually in iron and steel manufacture. The basic open-hearth furnaces are by far the largest consumers (12 to 14 million metric tons), but the electric furnaces, though with a much smaller output, work on little else but scrap, whilst another 4 million tons is used in iron foundries. Nearly one-half of the scrap supply normally arises from the iron- and steelworks themselves, during the processes of manufacture, and the remainder is purchased from home sources (particularly re-rolling works and other works engaged in processing iron and steel, and also engineering works, ship-breaking yards, and other works having obsolete plant to dispose of) or imported from abroad.

## The smelting and steel-making districts

### Location factors[3]

The British iron and steel industry affords numerous examples of 'geographical inertia' or 'industrial momentum'—the continuance of a human activity in a region, after some or all of the causes which gave rise to that activity have ceased to operate. By reason of the size and cost of its plant the manufacture of iron and steel tends to be one of the most inert of industries, and, rather than abandon their works and move to a better site, manu-

1. Manganese ore imports 1969: South Africa 129 thousand tons, Congo 64, USSR 31, Ghana 19, India 17, Brazil 77, total 431 thousand tons (metric).

2. Consumption of ferro-alloy materials, 1969 (thousand metric tons): nickel 13.9, molybdenum 3.7, tungsten 0.8, vanadium 0.8, cobalt 0.4; ferrochrome 52.9, ferrosilicon 94.0, ferromanganese 215.1.

3. A concise summary of the main locational characteristics of the British iron and steel industry will be found in an article entitled 'The location of the British steel industry', in the *Monthly Statistical Bulletin of the British Iron and Steel Federation*, **25**, no. 11, Nov. 1950.

facturers will go to great lengths to improve their efficiency, or their transport, or will specialise in certain types of produce. Slowly but surely, however, economic factors in the shape of competition from better situated producers will operate. If the industry originally set up has resulted in the accumulation of a large population in its neighbourhood, it is highly probable that production of some kind will continue by reason of the skilled

*Pig iron production (by districts)*
(thousand long tons)

| | 1913 | 1931 | 1937 | 1940[2] | 1950 | 1960 | 1965 | 1966 | 1969 |
|---|---|---|---|---|---|---|---|---|---|
| Derby, Leics., Notts, Northants, Essex[1] | 1 166 | 979 | 1 938 | 1 787 | 2 309 | 2 633 | 1 971 | 1 634 | 1 611 |
| Lancs and Yorks | 503 | 205 | 476 | 401 | 437 | 1 408 | 1 685 | 1 693 | 1 526 |
| Lincolnshire | 450 | 412 | 1 043 | 1 308 | 1 239 | 2 290 | 2 697 | 2 521 | 2 945 |
| NE Coast | 3 869 | 1 137 | 2 429 | 1 934 | 2 402 | 3 412 | 3 434 | 2 784 | 3 109 |
| Scotland | 1 369 | 154 | 497 | 659 | 739 | 1 299 | 1 675 | 1 313 | 1 908 |
| Staffs, Salop, Worcs, Warwick | 851 | 202 | 470 | 447 | 551 | 553 | 585 | 595 | 685 |
| South Wales and Monmouth | 889 | 280 | 814 | 962 | 1 232 | 3 141 | 4 718 | 4 611 | 4 034 |
| NW Coast | 1 163 | 404 | 825 | 705 | 824 | 1 028 | 695 | 559 | 571 |
| Total (long tons) | 10 260 | 3 773 | 8 493 | 8 205 | 9 633 | 15 763 | 17 460 | 15 710 | 16 390 |
| Total (metric tons) | 10 425 | 3 833 | 8 629 | 8 336 | 9 787 | 16 016 | 17 740 | 15 962 | 16 652 |

[1] Essex only since 1934. [2] War peak year—see footnote to next table.
1 long ton (2240 lb) = 1.016 metric ton.

labour there present; if the original industry was but small it must inevitably die out. Since much of our industry was built upon Coal Measure ores, which are now not worked at all, it follows that one of the main advantages formerly possessed by the iron industries of the coalfields has been lost. We must examine the producing areas individually in order to see how this change in location of the ore supplies has affected them.

It is important to realise that iron smelting and steel making can be and often are two quite separate industries, with different location factors. In the case of iron smelting, between 3 and 3.75 metric tons of raw materials and fuel are consumed per metric ton of pig iron, and the iron ore, which is the largest single item, naturally exerts the greatest influence on the location of the industry. Thus two major types of location are found: (*a*) on the orefields, particularly the low-grade Jurassic fields (e.g. Scunthorpe and Corby); (*b*) at ports, where foreign ores arrive (e.g. Middlesbrough, Workington, Cardiff, Dagenham—the first two having also the original advantage of nearby ore supplies, the third of a nearby source of coking coal). But the 'momentum' referred to above is also responsible for a third type of location: (*c*) on coalfields, where the original works were based on

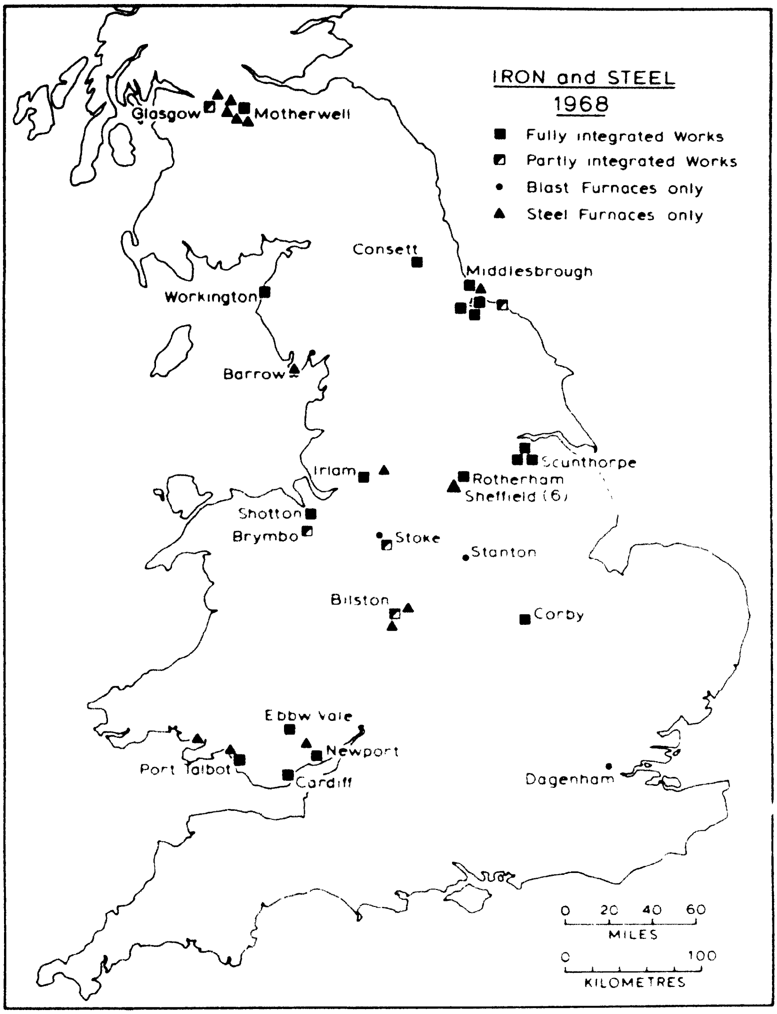



FIG. 167. The iron and steel industry in 1968

The special symbol for Sheffield represents six steelworks.

The number of blast furnaces in existence was 486 in 1921, 285 in 1937, 119 in 1952 and only 71 in 1969 (cf. Fig. 162). Open-hearth steel furnaces numbered 391 in 1952 and 181 in 1969. Electric furnaces numbered 321 in 1962 and 434 in 1969. There were 42 converters of various kinds in 1969. In addition to the works shown on this map, 106 other works, in various parts of the country, had small 'tropenas' converters or electric steel furnaces. Such furnaces belong to the engineering industry rather than to the primary production of steel; in 1969 they operated 15 converters and 348 electric furnaces.

local Coal Measure ironstones as well as suitable fuel (e.g. Consett, Ilkeston, Coatbridge, Bilston, Stoke-on-Trent).

The steel making industry has as its main raw materials iron, either molten or in pig form, and scrap. It may be located (*a*) adjacent to a smelting works, where molten iron from the blast furnaces can be converted

directly, without loss of heat, into steel; this type of situation—the 'integrated' works—is coming increasingly to dominate the British iron and steel industry (e.g. Middlesbrough, Scunthorpe, Workington, Ebbw Vale, Corby, Margam); (*b*) adjacent to its market (e.g. western South Wales, where almost all the output formerly went into the tinplate mills; and many scattered and mainly small works in various parts of the country which form part of steel foundries and engineering works); (*c*) in an engineering district where abundant scrap is locally available and the engineering works also form a market for the output (e.g. Wednesbury, Motherwell).

*Steel production* (*ingots and castings*) (*by districts*)
(thousand long tons)

| DISTRICT | 1913 | 1931 | 1937 | 1943[1] | 1950 | 1960 | 1965 | 1966 | 1969 |
|---|---|---|---|---|---|---|---|---|---|
| Derby, Northants, Notts, Lancs, Yorks (excluding Sheffield), North Wales | 512 | 363 | 1 511 | 1 683 | 2 048 | 3 589 | 3 927 | 3 653 | 3 822 |
| Lincolnshire | 241 | 392 | 1 299 | 1 243 | 1 562 | 2 579 | 3 086 | 2 770 | 3 233 |
| NE Coast | 2 031 | 1 142 | 2 825 | 2 525 | 3 353 | 4 813 | 4 790 | 3 857 | 4 373 |
| Scotland | 1 421 | 676 | 1 895 | 2 031 | 2 426 | 2 701 | 3 053 | 2 678 | 3 296 |
| Staffs, Salop, Warwick, Worcs | 365 | 419 | 702 | 727 | 856 | 1 554 | 1 757 | 1 769 | 1 982 |
| South Wales and Monmouth | 1 807 | 1 274 | 2 629 | 2 609 | 3 407 | 5 666 | 6 778 | 6 393 | 5 828 |
| Sheffield | 879 | 776 | 1 739 | 1 960 | 2 218 | 3 064 | 3 272 | 2 946 | 3 451 |
| NW Coast | 398 | 161 | 385 | 253 | 423 | 339 | 343 | 250 | 348 |
| Total (long tons) | 7 664 | 5 203 | 12 984 | 13 031 | 16 293 | 24 305 | 27 006 | 24 315 | 26 422 |
| Total (metric tons) | 7 787 | 5 286 | 13 192 | 13 240 | 16 554 | 24 695 | 27 439 | 24 704 | 26 845 |

[1] War peak year. The wartime peak of steel production was reached later than that of pig iron, for several sources of foreign ore were cut off and scrap was substituted. Thus the 1940 steel output consumed 6839 thousand metric tons (6731 thousand long tons) of pig iron and 7296 thousand metric tons (7181 thousand long tons) of scrap; the 1943 steel output consumed 6222 thousand metric tons (6124 thousand long tons) of pig iron and 8093 thousand metric tons (7965 thousand long tons) of scrap.

Naturally enough, in a country in which the industries are as old-established as they are in Britain (only four new localities of major importance have been added to the iron and steel map during the present century), and in which distances between coal, ore and ports are in no case great, many works fall into more than one category.

1. *Scotland.*[1] Of several dozen iron smelting works, all established between 1760 and 1860, only one remains (in a modernised form, of course); and nearly a century elapsed before the construction of a new plant at Ravenscraig, near Motherwell, in 1957. The first one, apart from a few charcoal

1. See H. Hamilton, *The Industrial Revolution in Scotland*, Chapters 7 and 8, for an excellent account of the development of the Scottish iron industry. Also K. Warren, 'Locational problems of the Scottish iron and steel industry since 1760', *Scott. geogr. Mag.*, **81**, 1965, 18–37.

furnaces erected on the west coast to use local timber and Furness haematite, was established by a Sheffield ironmaster in 1760, at Carron, near Falkirk, on a site within a few miles of the coast, where a good water supply was available, and close to clayband ore and coal reserves. The works quickly became one of the largest and most famous in Europe. Progress generally

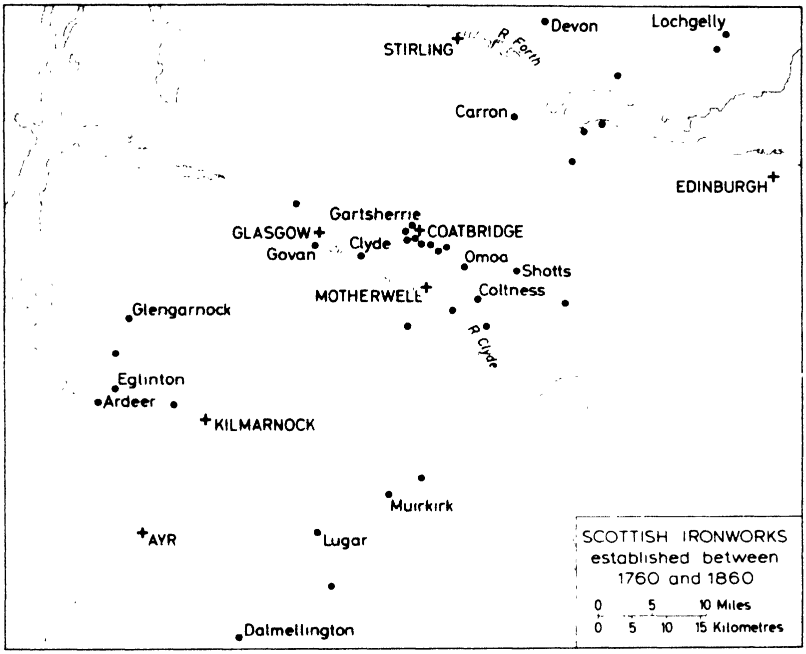



FIG. 168. Scottish ironworks established between 1760 and 1860

was particularly marked, however, after Neilson in 1828 rendered the blackband ores more efficiently usable by means of the hot blast. The output, only 9000 metric tons in 1806, rose to 213 000 metric tons in 1840, and in the 'fifties, with over 150 furnaces available, Scotland was producing a quarter of the entire British output of pig iron. After 1880 the production of blackband ores began rapidly to decline, and the ironworks, finding their ore supplies partly cut off, were obliged to import extensively from abroad. By distribution the smelting works fell into three main groups. The central group, clustered on the Lanarkshire coalfield, had its chief centres at Coatbridge, Airdrie, Motherwell, Wishaw, and Glasgow. Here the Monkland Canal and the Clyde, and later the railways, provided suitable means of transport for the bulky iron products, whilst the local 'splint' coals[1] and the

1. The 'splint' coal, one of the most constant of the Lanarkshire seams, is of a hard splinty character specially valuable for furnace purposes. 'It comes from the pit in big hard blocks which do not readily break up in the furnace under the weight of the overlying material, and the draught is thus kept open'. (*Mem. Geol. Surv., Economic Geology of the Central Coalfield of Scotland, Area V*, 1926, 73.)

blackband ores were the basis of this industry (cf. Fig. 143 and Fig. 164). The North Ayrshire group was centred on Irvine and Kilbirnie, with outlying plants at Lugar and Muirkirk; it had the same basis of ore and fuel. The third group, mostly post-1840 apart from Carron, straddled the upper Firth of Forth, using the coals and blackbands of the eastern part of the central coalfield in the Bo'ness area and of the Fifeshire coalfield around Lochgelly.

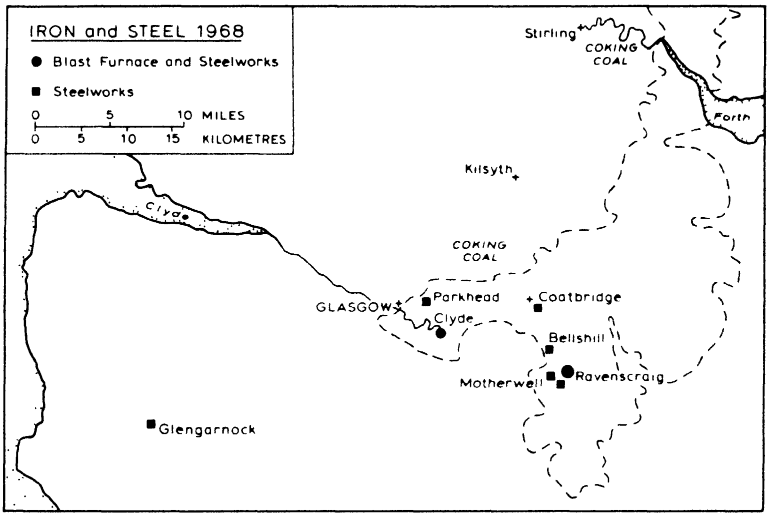



FIG. 169. The Scottish iron and steel industry in 1968
The dotted line is the boundary of the Coal Measures; the coking coal seams are in the Lower Carboniferous

The prosperity of the Scottish ironworks was seriously undermined by the falling off in the local ore supply, and the situation was aggravated by the approaching exhaustion of the 'splint' coals, which were used raw in the furnaces. These circumstances, together with the periods of depression which characterised the inter-war years, were largely responsible for completely changing the character of the Scottish iron smelting industry, by weeding out those works whose equipment or situation rendered them uneconomic. Pig iron production is now concentrated at two plants only—one near Glasgow and the new one near Motherwell. From more than 100 furnaces which existed in 1913 the number has fallen to only 6; many complete works have been demolished. Yet the pig iron output has since 1960 risen to a higher level than that of 1913. This concentration on a few large plants has been accompanied and aided by the production of coke from certain seams, such as the Kilsyth coking coal, which occur in the Lower Limestone Group (of Carboniferous Limestone age) in north Lanarkshire and Stirlingshire. New large furnaces, comparable with those in other parts of Britain, have been erected to use foreign ore and Scottish coke, and the two works are

fully integrated and possess their own coke ovens. Thus the small furnace producing foundry iron from local raw materials has vanished from the Scottish iron industry.

The steel industry is located for the most part in the neighbourhood of Coatbridge, Motherwell, Wishaw, and Glasgow. It grew up apart from the blast furnaces, depending originally on imported haematite pig iron and scrap from the local shipbuilding, ship-breaking, and engineering industries. During and after 1914–18 much of the plant was adapted for the production of basic steel, and in the 1950s about 90 per cent of the output was of the basic open-hearth variety. Scotland, however, has taken its full

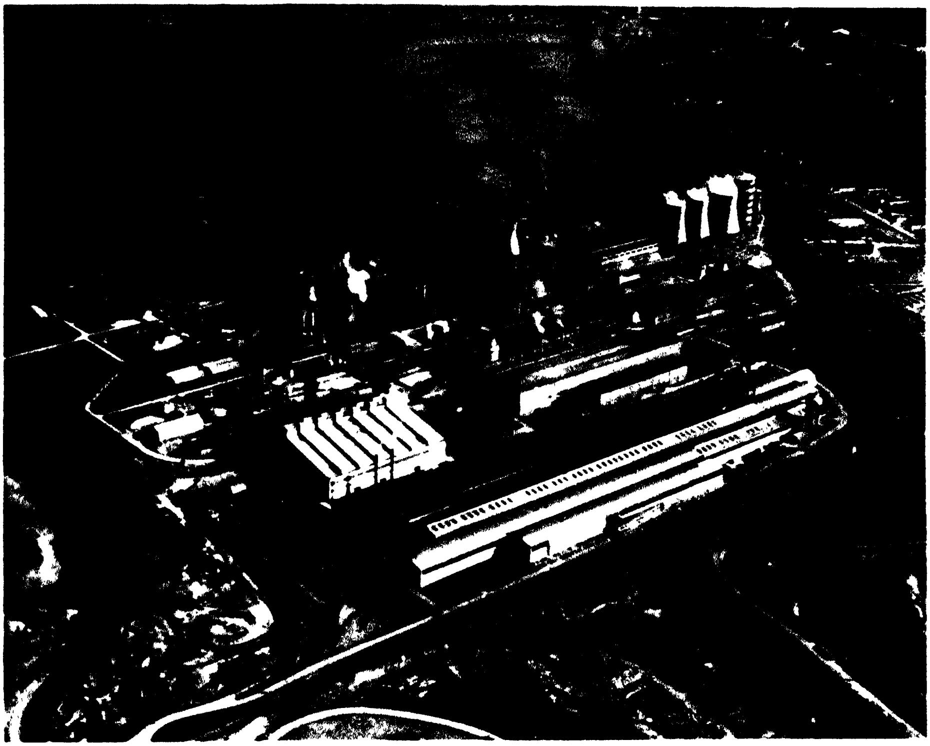


PLATE 19. Integrated steelworks at Ravenscraig, Motherwell

share of the recent technological advances, and only two-thirds of the steel is now made in open-hearth furnaces, the remainder coming from LD converters and electric furnaces. Much of the output, together with large quantities of imported semifinished steel, goes into the local shipbuilding and engineering industries, whilst the hot-strip mill at Ravenscraig, opened in 1963, provides sheet steel for the motor vehicle industry (Plate 19).

2. *Tees-side.*[1] The advantages of Tees-side for the setting up of iron and steel

1. See House and Fullerton, *Tees-side at Mid-century*, Macmillan, 1960; K. Warren, 'The shaping of the Tees-side industrial region', *Advmt Sci.*, 25, 1968, 185–99.

industries were unique. An abundant supply of ore in the Cleveland Hills, less than 8 kilometres (five miles) away from tide water at first, and later well within 32 kilometres (twenty miles) of Middlesbrough; ample supplies of the finest coking coal in the kingdom from southwest Durham, only 40 kilometres (twenty-five miles) away and available by existing railways; limestone in abundance from the Carboniferous Limestone in Weardale and dolomite from the Permian of East Durham: and a seaboard situation favourable, with the improvement of the estuary, for the export of the bulky products. It is little wonder that within twenty-five years of the commencement of the industry Tees-side was producing 1.75 million metric tons of

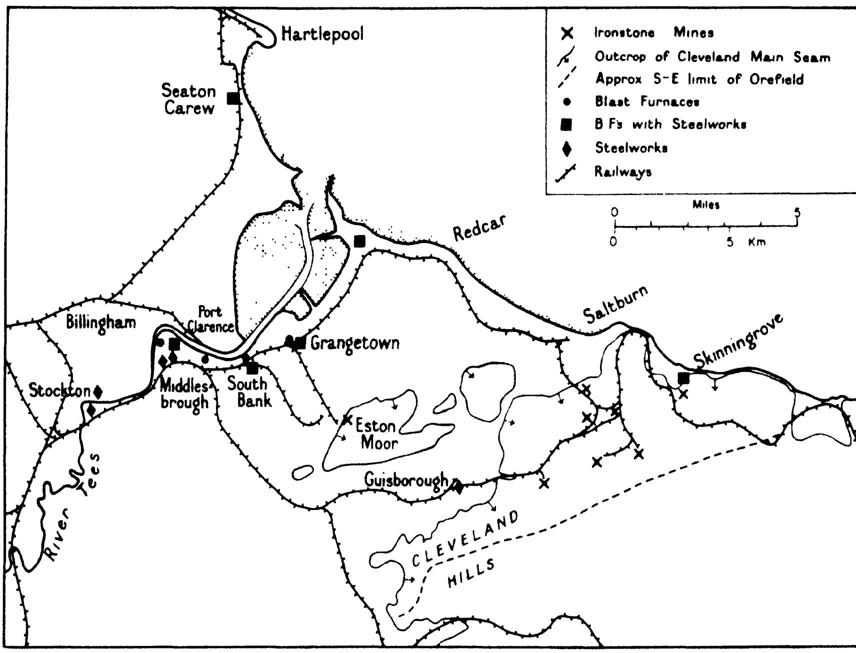



FIG. 170. The Tees-side iron and steel industry in the early 1950s

Apart from a reduction in the number of blast furnaces, the most important change has been the closure of all the iron ore mines. The Lackenby steelworks (1953) and beam mill (1958) lie just north-east of Grangetown

pig iron, or close on 30 per cent of the total British output. Moreover, after the introduction of the acid steel processes the coastal situation favoured the import of rich Spanish ores, which were rendered cheaper by the availability of a return cargo of coal from the adjacent coalfield, whilst the abundance of flat land alongside the estuary allowed ample room for the expansion of the works. All these advantages enabled Tees-side to build up the greatest iron and steel industry in the whole of Britain. The serious depletion of the local ores, however, combined with the stimulus which was given to the industry during 1914–18, brought about changes in the nature of the

industry. The pig iron output has never again approached the 1913 total (see table on p. 396), and none of it is now made from Cleveland ore. Sweden, Africa and the Americas supply rich ores from abroad; Northamptonshire and South Lincolnshire send a million tons per annum of lean ores. The bulk of the pig iron is converted into basic steel, and the once famous foundry iron production has virtually ceased. Both pig iron and steel are exported to Scotland and other coastal centres of the industry. Much of the haematite pig iron and steel made is sent to Sheffield for working up into the finer types of steel products. A large proportion of the steel production is absorbed by the local engineering and shipbuilding industries. The expansion of the steel industry during the First World War resulted in a vast improvement of the existing Tees-side steelworks plant and the erection of a new works at Redcar. Subsequently foreign competition resulted in renewed efforts to modernise the plant and to reduce working costs. As a result huge combines were formed, bringing under a single control the coke and ore supplies, the furnaces, and the steelworks, and even including the engineering industry and the marketing of the produce. An excellent example is furnished by Dorman Long, which united Dorman, Long & Co., Bell Bros., North-Eastern Steel Co., Bolckow, Vaughan & Co., and other smaller establishments. The industry was 'rationalised' and inefficient plant eliminated. For example, Port Clarence works (opposite Middlesbrough), with eleven blast furnaces, closed down in 1930 and was later demolished.

Steel-making capacity was increased in the 1950s by the construction of a new steel plant and beam mill at Lackenby; and a new ore terminal has been built to accommodate vessels of up to 100 000 tons.

The chief works in the northeast coast area away from the Tees are at Seaton Carew just north of the estuary, at Skinningrove, to the east, and at Consett.[1] These outlying centres are supported almost entirely by foreign ore.

3. *The West Coast.* The geographical basis of the iron and steel industry in West Cumberland and Furness was simple. Large supplies of rich haematite ore occurred within a few miles of the coast; the ore was obtained from the Carboniferous Limestone, which could be used as a flux; and the Durham coke lay not far away (by rail) across the Pennines (for the local Cumberland coal is not of first-class coking quality). Almost without exception, then, the works were located on, or quite close to, the sea-shore, and consequently, owing to the absence of a large industrial market in the vicinity, it was the export trade in pig iron which was chiefly developed, the exports being to Sheffield, coastwise to Belfast, South Wales, and Scotland, and

1. The location of the Consett works depended on the existence of a limited amount of clayband ironstone in the Coal Measures of the immediate vicinity; but as against its present disadvantageous situation regarding imported ore, it lies almost on top of the coking coal requirements, and not far from excellent limestone and silica rock deposits. It is a fully integrated works.

abroad. The first works (apart from the ancient charcoal furnaces)[1] were erected in 1841, but the greatest development came after the introduction of Bessemer steel, and nine new works made their appearance in as many years, between 1870 and 1879. The area built up a great reputation for high quality haematite iron and acid Bessemer steel, much of which was exported abroad or to other British industrial areas; and the shipbuilding industry at Barrow provided an additional local outlet. The depressions of the 1920s and 1930s decimated the industry (Fig. 171), which has still

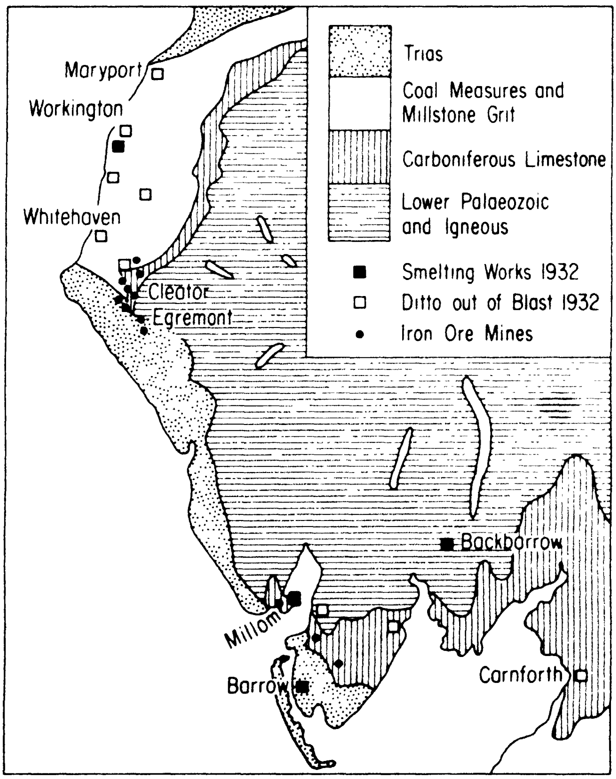



FIG. 171. Map illustrating the west coast iron and steel industry in the 1930s

Almost all the works marked as inactive in 1932 have since been demolished, of those active in 1932 only Workington remained in 1969. Only two mines remained in 1969, near Egremont, and none in the Furness peninsula.

further contracted in recent years; the blast furnaces at Barrow and Millom closed in 1968, and the industry is now represented only by the integrated works at Workington, which has blast furnaces partly fed by imported

1. The ancient Backbarrow works, founded in 1711, continued (in a modernised condition) to make charcoal iron well into the present century; with the virtual extinction of the local charcoal-burning industry it then turned to the use of coke, and it remained until the late 1960s as a rather odd, out-of-the-way relic.

(especially Norwegian) ores, and the only remaining acid Bessemer converters in the country, and by Barrow steelworks (where only the electric furnaces remain).

4. *South Wales.* South Wales illustrates admirably the changes that have been brought about in the location of the iron and steel industry owing to changes in geographical values. The earliest working after the introduction of coke smelting was in the northeastern part of the coalfield, in the uplands at the head of numerous valleys which flow down towards Cardiff and Newport; along a narrow belt, from Aberdare through Merthyr Tydfil, Rhymney, Tredegar, Ebbw Vale, and Blaenavon to Pontypool. Here the clayband ores were richest and the gentle dip of the Coal Measures on this

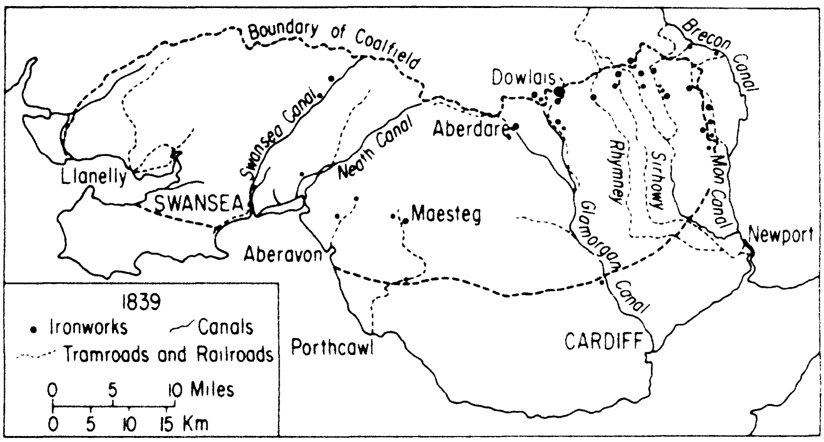



FIG. 172. South Wales iron smelting works, canals and chief tramroads, 1839

northern outcrop of the coalfield permitted the easy extraction of the ores and coal from quarries and adit mines. The setting up of the industry in this inland situation necessitated the growth of improved methods of transport, and the construction of tramroads and canals to the coast further stimulated the iron trade and encouraged the development of docks at Newport and Cardiff for exporting iron and coal (Fig. 172). There were other smelting works at Maesteg and Cwmavon, where the median anticline of the coalfield (cf. p. 315) brought coal and ironstone to the surface. A vast industry developed, reaching its maximum in the 1860s when there were 200 blast furnaces and over 1350 puddling furnaces for wrought iron manufacture.

The introduction of the acid steel industry in the 'sixties, with its accompanying need for non-phosphoric ore, started slowly but surely to undermine the basis upon which the existing iron industry had been built. Interest now centred on the import of rich haematite from Spain. The momentum of the northeastern area sufficed to attract the steel industry to that area, and several large works grew out of the existing smelting and wrought iron works. Dowlais was in fact the largest works in the world at one time.

But this prosperity could not last; all the haematite ore had to be dragged up the valleys from the ports, and the introduction of the basic process gave no relief since by that time the local clayband ores were either exhausted or rapidly becoming uneconomic to work; and competition from better-situated producers in other parts of Britain was intense. So one by one, from the 1880s onwards, the great works—Dowlais, Cyfarthfa, Sirhowy, Blaenavon, and others—closed down, and the last survivor, Ebbw Vale, ceased work in 1929.[1]

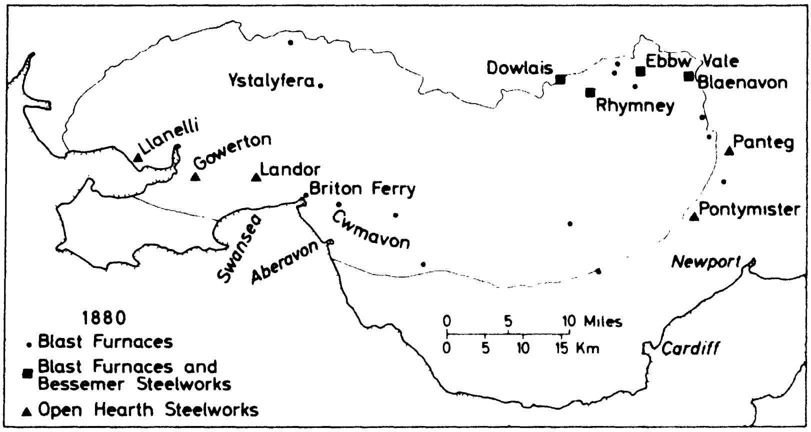



FIG. 173. The South Wales iron and steel industry in 1880

Meanwhile two other trends had developed. First, following the discovery by Siemens in the late 1870s that mild open-hearth steel made an excellent foundation for tinplate, several new steelworks—based on imported pig iron and scrap—were set up in the southwestern part of the coalfield, close to the ports and within the area where the tinplate industry was already largely concentrated—as at Llanelli, Bynea, Gorseinon, Gowerton, Swansea, Briton Ferry, and Port Talbot. A somewhat similar development took place in the east—e.g. at Panteg and Pontymister. Secondly, new 'integrated' iron- and steelworks were set up on the coast—indeed, on the dockside—at Cardiff and at Margam (Port Talbot). Here, obviously, with Spanish, French, and North African ores readily available by sea, was a better situation for the industry than 24 kilometres (fifteen miles) inland and 300 metres (1000 ft) above sea-level.

The extinction of the industry in the northeastern area was the major factor in the severe incidence of the depression, with its attendant unemployment problem, in that part of South Wales, between the wars. The existence of so much 'social capital' in the area, however, prompted the

1. See D. G. Watts, 'Changes in location of the South Wales iron and steel industry, 1860–1930', *Geography*, 53, 1968, 294–307.

Government in 1936 to encourage the firm of Richard Thomas & Co., which at that time was considering abandoning its interests in South Wales and setting up a new plant at Scunthorpe, to embark on a large scheme for the rehabilitation of Ebbw Vale; and at a cost of over £10m, a vast new integrated works was constructed, with blast furnaces, coke ovens, basic Bessemer and open-hearth furnaces, continuous hot-strip mill and tinplate works. The Bessemer process was first chosen as being less expensive in fuel than the open-hearth, and the need for high-phosphorus iron for basic Bessemer steel entailed the importation by rail of Northampton Sands ironstone from the Wellingborough district (where the Irthlingborough mines had been worked by the previous Ebbw Vale company). Ebbw Vale is now once again one of the greatest single producing units in the country; it has, however, substituted LD converters for basic Bessemer, and has added a continuous galvanising plant.

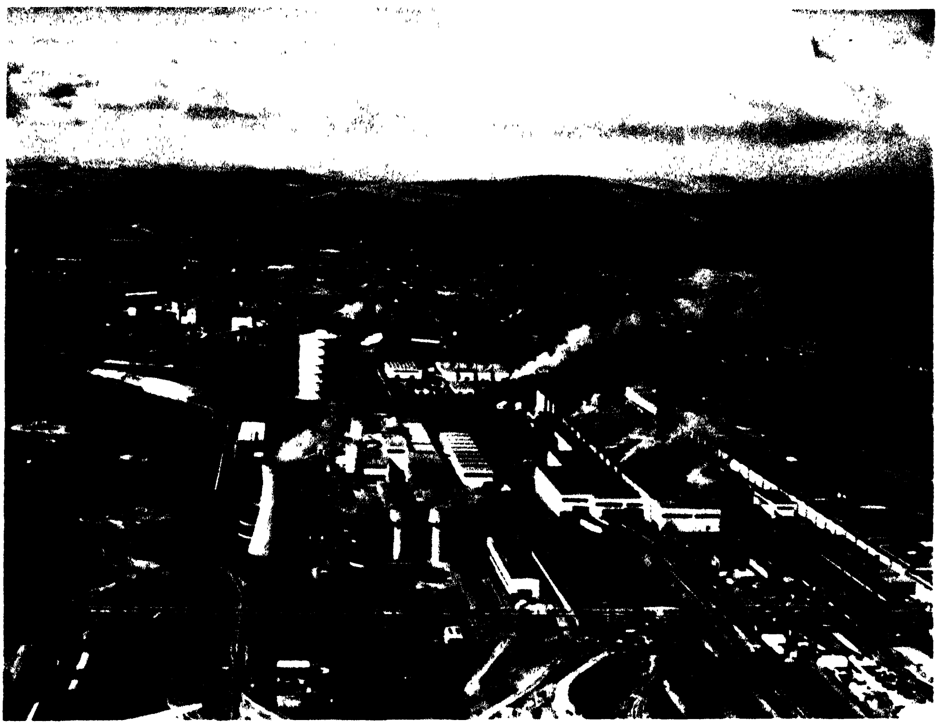


PLATE 20. Integrated steelworks at Margam, Port Talbot

The success of Ebbw Vale, and particularly the economies to be reaped in tinplate manufacture by the hot-strip process (see below, p. 422) prompted the formation by several South Wales steel firms of the Steel Company of Wales, which in 1947 began a £60m project for the reconstruction of the Margam iron- and steelworks (which is of course dependent on foreign ores) and the installation alongside it of a continuous hot-strip mill (the Abbey

works), together with associated cold rolling mills and tinning works at Trostre, near Llanelli and at Velindre near Swansea. These two vast tinplate producing concerns, Ebbw Vale and Margam–Trostre–Velindre, have rendered redundant all the old tinplate mills and most of the smaller steelworks (cf. p. 422); but the hot-strip process also produces other sorts of steel sheet besides that for tinplate, in particular, for motor car bodies.

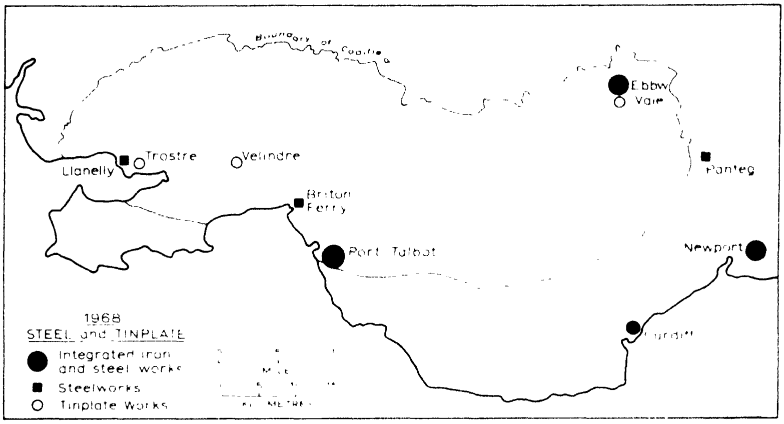



FIG. 174 The South Wales steel and tinplate industry, 1968

Another vast new works—the Spencer works, near Newport, was opened in 1962; with its blast furnaces and LD converters this adds another 1.5 million metric tons to the steel making capacity of South Wales, which is now by far the largest producing district in Great Britain.

So the present picture in South Wales, with a few very large integrated works and a few separate steelworks, is indeed a very different one from that of a hundred years ago – more so, perhaps, than in any other area except Scotland, and the differences are due fundamentally to changes in industrial technique and in the sources of raw materials.

5. *Lincolnshire.*[1] In Lincolnshire, where the first furnace was lighted in 1864, the localisation of the works is due entirely to the existence of the thick, though lean, Lower Lias ore in the neighbourhood of Scunthorpe and Frodingham. The greater thickness of the orebed here and its occurrence over a comparatively small and compact area has permitted a far greater concentration of the smelting industry on this field than was the case, for example, in Northamptonshire. The area is well situated with regard to fuel supplies and export facilities. The nearest mines of the Yorkshire coalfield (which produces good coking coal) are less than 24 kilometres (fifteen miles) to the west, and the port of Grimsby lies only 40 kilometres (twenty-

1. D. C. D. Pollock: 'Iron and steel at Scunthorpe', *East Midland Geogr.*, 3, 1963, 124–38.

five miles) to the east. The limy nature of the ore, as we have seen, necessitates the import of siliceous Northampton Sands ore from South Lincolnshire, but the presence of appreciable quantities of manganese renders it rather more suitable for basic open-hearth steel making than the Northamptonshire ore. Owing to this fact, and to the compact nature of the industry, this group of works received a marked stimulus during 1914–18, further emphasised during the reconstruction that followed the depression of the 1930s, and the production of steel is now more than ten times what it was in 1913. The plant comprises three huge integrated works, Appleby-Frodingham, Lysaght's and Richard Thomas. The ironstone field is estimated to have a future of at least 200 years before it, and this, together with the relative ease of access to imported ore, provides an assured future for the industry. The momentum of other areas may prevent the rise of any great engineering industry, but Scunthorpe will remain a pillar of strength as a producer of the raw materials of that industry. Pig iron is sent to Yorkshire, Lancashire, Staffordshire, and Scotland, and much of the steel output goes into constructional engineering.

6. *The western Midlands (Black Country, etc.)*. Even in the days of charcoal smelting South Staffordshire, by virtue of its accessible coal supplies,[1] developed an extensive finished iron industry based upon bar iron obtained either from Shropshire and Worcestershire or imported *via* the River Severn from the Forest of Dean and Sweden. Furnaces, forges and slitting mills made use of every available stream for power, and there was especial concentration in the Stour valley.[2] The introduction of coke smelting at once placed the Coalbrookdale area and South Staffordshire in a more favourable position. Rich coal and iron seams, together with fireclays, occurred in the same measures, a supply of flux was locally available in the Wenlock limestone hills of Dudley, and the people were already skilled in metal working. The result was the creation of that vast smelting industry which earned for the South Staffordshire region its unenviable title of 'Black Country'.[3] At the beginning of the nineteenth century the two counties of Staffordshire and Shropshire accounted for 40 per cent of the pig iron production of Great Britain. In North Staffordshire the clayband ores and coking coals of the western part of the coalfield began to be used in the late eighteenth century, and the utilisation of the blackband ores after 1840 brought the smelting industry into the Potteries area.

The Black Country reached its peak in iron production in the late 1850s, with about 180 blast furnaces, but already the local ironstones were showing signs of physical and economic exhaustion and a declining iron output

1. Coal furnaces were used to heat the iron for forging.
2. B. L. C. Johnson, 'The Stour Valley iron industry in the late seventeenth century', *Trans. Worcs. archaeol. Soc.*, 1950, 35–46.
3. See *Birmingham and its Regional Setting*, British Association Handbook, 1950, pp. 161–86, 193–210, and 229–48.

became increasingly dependent on Northamptonshire ores.[1] Wrought iron production, partly assisted by Northamptonshire pig iron, went on increasing until the 'seventies, when there were over 2100 puddling furnaces, but after that appreciable changes took place; iron smelting declined still further, and steel manufacture began to replace that of wrought iron, with an increasing concentration on iron-using industries rather than iron-making. There are now only six furnaces left in Staffordshire, and the last

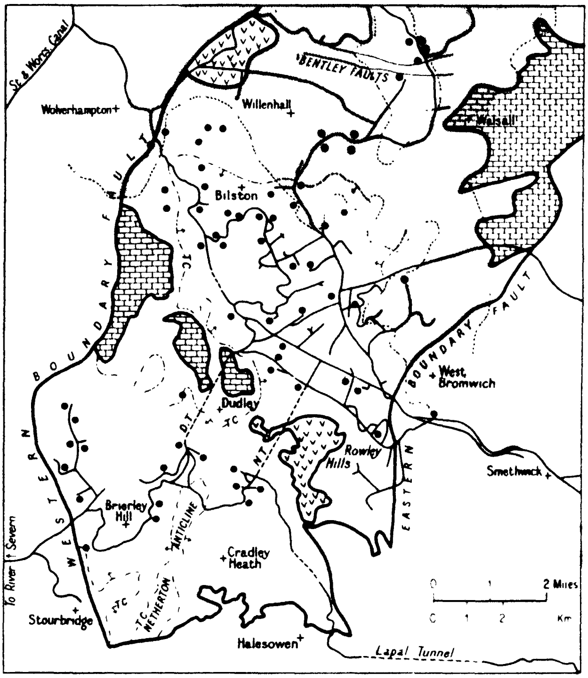



FIG. 175. The Black Country iron industry in the mid-19th century

Within the coalfield are shown (i) Exposed Coal Measures (covered in some areas, however, by Etruria Marl), (ii) Glacial Drift (stippled), (iii) Carboniferous volcanics (V-symbol), (iv) Silurian inliers (brick-work symbol); (v) Outcrop of Thick Coal (T C), with arrow indicating dip. Also shown are all the canals and branches, and (black dots) all the ironworks in existence in the 1850s. Note that almost every ironworks lay alongside a canal, and many were served by their own branches and basins. For the ultimate destinations of the canals passing beyond the edge of the map, see Fig. 239.

of the small works left on the Shropshire coalfield, at Oakengates, has been demolished. In North Staffordshire, at Etruria, and in the south, at Bilston, Jurassic ores from Northamptonshire, and some imported ores are used, whilst the small Goldendale works in Stoke-on-Trent uses nothing but

1. The South Staffordshire output of pig iron was 606 500 metric tons (597 000 long tons) in 1858. By 1884 it had declined to 283 500 metric tons (279 000 long tons), 80 per cent of which was made from Northamptonshire ore.

scrap. North Staffordshire, it is true, has coking coal on the spot, but the Shelton works is no longer fully integrated,[1] and Bilston's coke is derived from South Wales. The West Midland iron and steel industry is thus running on 'industrial momentum'. The true Black Country now produces no coal and no iron ore, and, as a result, has come to specialise to an increasing extent in steel making, fostered by the abundance of scrap available from the engineering industries. There are steelworks at Bilston, Round Oak, and Wednesbury. Foundry pig iron is imported from Northamptonshire for working up into cast iron articles, but the last remaining wrought iron works, which produced ships' chains and anchors, closed down in 1961.

7. *The remaining areas* (*except Sheffield*). The remainder of the British iron and steel industry falls into several groups. The former general dominance of pig iron production for foundry work has given way, except in Derbyshire, to a greater concentration on steel. Most of the works are supplied with ore from the marlstone and Northampton Sands fields (cf. Fig. 166). Three principal groups of furnaces may be noted:

(*a*) *Derbyshire and south Yorkshire*, grouped around three centres, in south Derbyshire (Ilkeston), in northeast Derbyshire (Chesterfield), and in south Yorkshire (Rotherham).[2] All these works owed their origin to the clayband ores which were formerly mined in conjunction with the valuable coal seams which occur near the base of the Middle Coal Measures. In a fourth area, around Leeds and Bradford, the Black Bed ironstone and the Better Bed coal were used, and this region was long famous for 'Best Yorkshire' wrought iron. The last surviving works, at Low Moor, was dismantled in 1938, and an alloy steel works has taken its place. In south Yorkshire the Tankersley ironstone and the Silkstone and Park Gate coals provided the basis for the industry which still flourishes in the Rotherham area, where Park Gate is a fully integrated works and Renishaw a small blast-furnace plant producing iron for the steelworks of companies with which it is associated. Farther south, in the Chesterfield area, the Brimington anticline brought the Silkstone coal and several useful ironstone seams nearer to the surface and so localised the furnaces (now dismantled) at Sheepbridge and Staveley, where the speciality is iron pipes for water and gas mains. At Clay Cross an ironworks – also closed – was started in 1847 to provide an outlet for the surplus coke produced by the ovens erected to supply Midland Railway locomotives – perhaps the oddest location factor in the whole of the British iron industry. Farther south still the Erewash valley anticline, bringing the valuable Top Hard (Barnsley) coal to the surface, localised a group of furnaces of which the Stanton works near Ilkeston, world famous for iron

1. Coking coal is mined within a stone's throw of the Shelton works, but when the coking plant needed complete reconstruction in 1968 it was in fact abandoned, and the coal now goes by rail to Shotton on Deeside for coking, returning to Shelton in the same wagons!

2. See K. Warren, 'The Derbyshire Iron Industry since 1780', *E. Midland Geog.*, **16**, 1961, 17–33.

pipes, is the only survivor.[1] All these works now depend entirely on Jurassic ores, and their output (except at Park Gate) is concerned far more with pig iron and foundry products than with steel. At Stanton a recent development is the replacement of the cupolas used for re-melting pig iron and scrap by Kaldo vessels which produce molten iron for the pipe-spinning process.

(*b*) *South Lancashire and North Wales.* The existence of a small quantity of coking coal and the local demand for textile machinery, together with the availability of imported ore supplies *via* Liverpool, gave rise to the iron industry in South Lancashire, and in North Wales the usual association of coal and ironstone in the Flint and Denbigh coalfield led to its development. What remains is either modern or specialised. The smelting works at Wigan and Darwen have long been extinct, and the only works in South Lancashire is the modern plant at Irlam, alongside the Ship Canal; this depends on ore from Northamptonshire and abroad. The huge steelworks at Shotton, to which blast furnaces and coke ovens were added in 1953, are likewise modern; though on Deeside they depend on Birkenhead for imports and exports. The Mostyn ironworks, also on the Dee estuary, which made ferro-alloys, has closed, and the only survivor of the old industrial régime is the Brymbo iron- and steelworks, near Wrexham, which played almost as important a part as Coalbrookdale in the early history of the iron industry.

(*c*) *Northamptonshire and Leicestershire.* In Northamptonshire, as at Scunthorpe, the local ore supplies gave rise to an industry away from the coalfields.[2] The start was slow, for the inland situation and the great momentum possessed by the Midlands as iron producers prevented the rise of an industry comparable with that which developed, based on similar ores, on Tees-side. Moreover, the distance from coal and from the coast prevented the rise of a basic steel industry, and the phosphoric ore produces an easily flowing pig iron which is admirably adapted for making cast iron articles. Until recently therefore the area remained as a producer mainly of foundry and forge pig iron for the vast metallurgical industries of Staffordshire, and the scattered foundry and engineering industries of the southeastern portion of Great Britain. The chief centres of the smelting industry were near Melton Mowbray, in Leicestershire, and at Kettering, Wellingborough and Corby, in Northamptonshire. The last-named village, which saw its first blast furnace in 1910, has since 1933 been transformed into an industrial

1. Both the Silkstone and the Top Hard seams produce hard coal not unlike the Scottish 'splint'; during the nineteenth century many of the Derbyshire ironworks—and there were twenty-six in all—used raw coal rather than coke, and it was only in the first decade of the present century that the introduction of by-product coke ovens altered the balance; the small coal-using furnaces were inefficient, and the collapse of the wrought iron industry in the 1920s removed their market and brought about their demise.

2. S. H. Beaver, 'The development of the Northamptonshire iron industry 1851–1930' (in *London Essays in Geography*, Longmans, 1951, Ch. 3).

town[1] by one of the outstanding developments of the century. Stewarts and Lloyds erected a huge plant, containing coke ovens, blast furnaces, Bessemer and open-hearth steel furnaces, continuous hot-strip rolling mill, and a tube factory, in the heart of the Northamptonshire ironfield. The distance from a coalfield, the requirements of the tube industry, and the phosphoric character of the ores, led to the adoption of the basic Bessemer process, but this has been replaced by the oxygen-using LD process (cf. p. 379).

The declining market for foundry iron, however, has led to the closure of all the remaining blast-furnace works, and Corby thus remains alone, another witness to changing industrial techniques.

Last amongst the 'remaining areas' is Essex. Here, in 1934, at Dagenham on Thames-side, the Ford Motor Co. established coke ovens and a blast furnace, with a motor vehicle assembly plant alongside. Both ore and coal arrive by sea.

8. *Sheffield.*[2] Sheffield must be considered separately, because its industry is so very different from that of the remainder of the region in which it is situated. In common with the neighbouring areas, the Don valley and its tributaries developed, as early as the twelfth century, an iron industry based upon Coal Measure ironstones, local charcoal supplies, and plentiful water power. The Carboniferous sandstones of this region making excellent grindstone material, specialisation commenced in the manufacture of cutlery, and this was encouraged by the settling of skilled Flemish immigrants in the district in the sixteenth century. The impurity of the local ores rendered necessary the import of pure bar-iron from Spain and central Sweden for the finer work. Thus, over 400 years ago, began a branch of the steel industry which, largely owing to the 'deposit' of skilled labour which has accumulated, has remained localised in this region. The only essential changes which have occurred are (*a*) the concentration of the more recently developed heavy steel industries in the Don valley between Sheffield and Rotherham, whilst the manufacture of cutlery and the lighter types of goods is more localised higher up in the Sheaf valley in the centre and south of Sheffield; and (*b*) the specialisation in the finest types of steel goods and in such articles as need a large amount of skilled labour expended upon a small quantity of raw material; this was a result of the inland position and the absence of local ore supplies.

The development of the steam engine and of iron and steel ships gave Sheffield new opportunities for producing fine steel forgings for the crankshafts and axles and, later, huge castings for turbine engines; the constant necessity for improvement in armour-plating and in guns and shells for

1. K. C. Edwards, 'Corby – a New Town in the Midlands', *Tn Planning Rev.*, **22**, 1951, 122–31.
2. For a brief history of the Sheffield steel industry, see Lord Aberconway, *Basic Industries of Great Britain*, Chapter 3; also R. N. Rudmose Brown, 'Sheffield: its rise and growth', *Geography*, **21**, 1936, 175–84; and *Sheffield and its Region* (British Association for the Advancement of Science, Handbook 1956), Chapters 15 and 16.

destroying it opened up further fields;[1] the perfection of high-speed tool steels since 1900 has expanded the steel market still further; whilst the development of chrome-iron alloy, which produces stainless steel,[2] just before the First World War, and the subsequent use of this material not only in the cutlery trade but also for an expanding list of products in the engineering industry, have ensured that, despite its inland position, Sheffield's accumulation of plant and skill will continue to maintain the special branches of the steel industry for which the town is justly famed. The industry underwent a considerable expansion in productive capacity during 1914–18, and a further and even greater stimulus was provided by the Second World War, so that the output in the 1960s was more than three times greater than that of 1913. No pig iron is made in Sheffield, and by far the most important raw material is scrap. Sheffield is almost the only remaining home of the acid open-hearth furnace, and it contains nearly a half of all the electric steel furnaces in the country. In recent years over two-thirds of the local steel output has been derived from electric furnaces, and the city produces 60 per cent of the entire British output of electric steel. In alloy steel the dominance is similar, partly of course since about 80 per cent of all the alloy steel made is produced in electric furnaces. In recent years Sheffield has produced about 60 per cent of the national output of alloy steel.
*Ireland.* The only steelworks in Ireland is on an island in Cork Harbour; it is based on imported scrap, and the furnaces are oil-fired; in addition there is a small galvanising plant. It serves the Irish market.[3]

## The uses of British steel

The following table shows some of the major uses to which the produce of British steelworks is put. An amount of the order of 6 million metric tons a year consists of semifinished steel in the form of blooms, billets, slabs and bars which go to the re-rollers for conversion into finished products. A further 3 million metric tons or so are exported, and almost as much goes into the stockyards of the merchants who supply the multifarious needs of small users. It is worthy of note that the motor vehicle industry is now by far the largest single consumer of steel.

1. Several armour-plate firms, e.g. Brown, Cammell Laird and Vickers, extended their interests and use their Sheffield products in their own shipyards.
2. See Marshal and Newbould, *The History of Firths*, 1924. Stainless steel contains about 18 per cent by weight of chromium and 8 per cent nickel.
3. D. A. Gillmour, 'The Irish Steel Industry', *Irish Geog.*, **6**, 1969, 84–90.

*Uses of British steel* (thousand long tons)

| USER | 1965 | 1967 | 1969 |
|---|---|---|---|
| Stockholding merchants | 3 003 | 2 756 | 4 382 |
| Motor vehicle industry | 1 870 | 1 568 | 1 802 |
| Industrial plant and steelwork | 1 666 | 1 330 | 1 332 |
| Wire manufacturing | 1 242 | 1 045 | 1 183 |
| Machinery (non-electrical) | 1 170 | 952 | 1 148 |
| Electrical machinery and goods | 553 | 439 | 478 |
| Agricultural machinery | 131 | 107 | 128 |
| Shipbuilding and marine engineering | 585 | 418 | 574 |
| Railway rolling stock | 221 | 156 | 134 |
| Coal mining | 464 | 475 | 398 |
| Construction (civil engineering) | 794 | 589 | 630 |
| Cans and metal boxes | 597 | 658 | 691 |
| Hollow-ware | 184 | 146 | 185 |
| Drop-forgings | 762 | 629 | 813 |
| Nuts, bolts, screws, etc. | 231 | 220 | 217 |
| Other users | 3 368 | 3 781 | 4 185 |
| Exports | 3 350 | 3 712 | 3 374 |
| Semi-finished steel (blooms, etc.) | 7 097 | 5 875 | 7 049 |
| Total | 27 288 | 24 856 | 28 703 |
| Total (metric tons) | 27 726 | 25 255 | 29 162 |

## The iron and steel trade

The following table gives details of iron and steel imports for certain years.

It will be observed that much of the import is of 'raw' or 'semifinished' materials, destined (pig, blooms, and billets) for remelting and processing, or (sheets, plates, and rods) for further fabrication. The postwar expansion of British output seems to be reducing the quantity of imports, and our nearest continental neighbours are taking an increasing share of the trade. But it is a trade that fluctuates widely from year to year.

[*chapter continues overleaf*]

*Iron and steel imports by varieties and countries*
(thousand long tons)

| | ITEMS | 1913 | 1933 | 1937 | 1950 | 1960 | 1965 | 1969 |
|---|---|---|---|---|---|---|---|---|
| VARIETIES | Blooms and billets | 514 | 230 | 435 | 161 | 220 | 16 | 576 |
| | Sheet and tinplate bars | 345 | 85 | 151 | 23 | 19 | | - |
| | Steel bars, angles, and shapes | 134 | 187 | 72 | 8 | 76 | 103 | 268 |
| | Plates and sheets | 169 | 36 | 49 | 93 | 625 | 250 | 462 |
| | Iron bars, rods, and angles | 200 | 15 | 25 | | 1 | | |
| | Hoops and strips | 72 | 79 | 72 | 6 | 20 | 36 | 40 |
| | Girders and beams | 109 | 77 | 71 | 13 | 3 | 9 | 35 |
| | Wire rods | 95 | 42 | 97 | 66 | 88 | 34 | 57 |
| | Pig iron | 185 | 93 | 644 | 195 | 223 | 314 | 169 |
| | Other varieties | 408 | 127 | 423 | 192 | 407[1] | 438[2] | 1140[3] |
| | Total | 2231 | 971 | 2039 | 757 | 1682 | 1200 | 2747 |
| | Total (metric tons) | 2267 | 987 | 2072 | 769 | 1709 | 1219 | 2791 |

[1] Includes 213 Ferro-alloys. [2] Includes 304 Ferro-alloys.
[3] Includes 325 Ferro-alloys and 80 high-pressure conduits for hydroelectric plants; also 424 steel ingots.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| COUNTRY OF CONSIGNMENT | Belgium | 583 | 468 | 528 | 95 | 115 | 57 | 124 |
| | United States | 154 | 2 | 315 | 62 | 331 | 28 | 248 |
| | France | 37 | 113 | 316 | 301 | 65 | 52 | 79 |
| | Luxembourg | * | 57 | 134 | 42 | 17 | 13 | 6 |
| | Netherlands | 7 | 11 | 28 | 46 | 191 | 143 | 518 |
| | Canada | * | * | 164 | 39 | 286 | 72 | 71 |
| | Germany | 1198 | 55 | 133 | 71 | 127 | 171 | 155 |
| | Sweden | 209 | 23 | 105 | 14 | 53 | 114 | 211 |
| | Other Countries | 43 | 242 | 316 | 87 | 497 | 550 | 1335[1] |
| | Total | 2231 | 971 | 2039 | 757 | 1682 | 1200 | 2747 |
| | Total (metric tons) | 2267 | 987 | 2072 | 769 | 1709 | 1219 | 2791 |

* Not available. 1 long ton (2240 lb) = 1.016 metric ton.
[1] Includes 355 Norway, 127 USSR.

In the next table exports are similarly enumerated.

The 1913 figure has never since been reached, and probably, with world output rising rapidly, it never will be. Naturally enough, it is 'finished' materials rather than 'raw' iron and steel which are exported, and the increasing relative importance of tubes and pipes is a reflection partly of increased British output (notably from Corby) and partly of increased world demand for such products for use in oil transmission (note e.g. exports to Iran) and as tubular scaffolding. The destination of the exports no longer shows the marked Commonwealth bias characteristic of former years; the USA and our European neighbours are now the main customers.

*Iron and steel exports by varieties and countries*
(thousand long tons)

| | ITEMS | 1913 | 1933 | 1937 | 1950 | 1960 | 1965 | 1969 |
|---|---|---|---|---|---|---|---|---|
| VARIETIES | Plates and sheets | 204 | 213 | 387 | 471 | 689 | 1177 | 1086 |
| | Pig iron | 945 | 108 | 153 | 35 | 146 | 88 | 80 |
| | Tubes and pipes | 400 | 273 | 376 | 510 | 735 | 386 | 425 |
| | Railway rails | 500 | 56 | 148 | 175 | 90 | 267 | 128 |
| | Steel bars and angles | 251 | 107 | 231 | 522 | 497 | | |
| | Miscellaneous | 2669 | 1165 | 1314 | 1468 | 1468 | 2205 | 2393 |
| | Total | 4969 | 1922 | 2609 | 3181 | 3360 | 4123 | 4112 |
| | Total (metric tons) | 5049 | 1953 | 2650 | 3232 | 3414 | 4189 | 4178 |

| | | 1913 | 1933 | 1937 | 1950 | 1960 | 1965 | 1969 |
|---|---|---|---|---|---|---|---|---|
| COUNTRY OF DESTINATION | Australia | 567 | 120 | 149 | 462 | 198 | 111 | 52 |
| | South Africa | 261 | 170 | 304 | 191 | 82 | 195 | 47 |
| | Iran | 4 | * | 70 | 101 | 78 | 80 | 128 |
| | India, Pakistan, and Ceylon | 896 | 187 | 258 | 253 | 364 | 178 | 144 |
| | New Zealand | 154 | 54 | 122 | 179 | 147 | 145 | 90 |
| | Netherlands | 146 | 43 | 105 | 78 | 118 | 97 | 110 |
| | British East Africa | 19 | 7 | 21 | 96 | 46 | 40 | 44 |
| | British West Africa | 46 | 18 | 68 | 95 | 90 | 67 | 79 |
| | Argentina | 358 | 110 | 192 | 66 | 87 | 109 | 79 |
| | Finland | * | 18 | 30 | 78 | 52 | 90 | 106 |
| | Canada | 187 | 123 | 169 | 242 | 200 | 219 | 139 |
| | Irish Republic (Eire) | * | 33 | 65 | 101 | 63 | 86 | 162 |
| | Other countries | 2331 | 1039 | 1056 | 1239 | 1854 | 2706 | 3232[1] |
| | Total | 4969 | 1922 | 2609 | 3181 | 3360 | 4123 | 4112 |
| | Total (metric tons) | 5049 | 1953 | 2650 | 3232 | 3414 | 4189 | 4178 |

* Not available. [1] Includes USA 782, Sweden 206, Spain 288, Italy 134
1 long ton (2240 lb) = 1·016 metric ton.

# 17
# Iron and steel: the secondary industries

The iron and steel industry obviously does not come to an end with the casting of steel ingots and the rolling of plates, bars, and rails. Ingots, plates, and bars, although the finished products of the steel furnaces and mills, are the raw materials of a number of other industries, which thus depend for their existence upon the output of the home steel industry or upon the imported material. Chief amongst these are shipbuilding, tinplates, galvanised sheets, rails, tubes and pipes, constructional steelwork, iron castings (stoves, radiators, cylinder blocks, etc.), wire and wire products (netting, nails, etc.), and the various industries concerned with the manufacture of engines and machinery, and their constituent parts (cf. p. 436). To describe all of these would be impossible within the limits of a single chapter. We may, therefore, concentrate our attention on some which are geographically most interesting. Three groups of industries will be studied:

(*a*) *The tinplate industry* and its allies, concerned with the covering of thin steel sheets with a coating or film of tin, zinc, or a mixture of tin and lead;
(*b*) *The shipbuilding industry*, employing vast quantities of thick steel plates and girders; and
(*c*) The various *engineering industries*, depending for their raw materials upon foundry and forge iron from the blast furnaces and various forms of 'semifinished' steel from the mills. Some branches of engineering industry – the building of steam locomotives for example—have declined: in contrast there is the huge expansion of the automobile and aircraft industries and of the complex electrical machinery industry.

A few simple geographical considerations will reveal certain definite localising factors in each of these groups. In the case of the tinplate industry the bulkiest raw material is the steel plate which is to be coated; moreover, the tin has to be imported and much of the produce is destined for export. It would seem, then, that a situation within one of the great seaboard steel-producing areas is most favourable. With shipbuilding we shall likewise expect to find a concentration mainly on those navigable estuaries or sheltered waters where the heavy iron and steel industry is also developed. The engineering industries, however, being concerned, generally speaking,

with more valuable products, do not show the same tendency to be concentrated in close proximity to the parent industry; in fact, since the finished articles are usually more costly to transport than the raw materials of which they are composed, and since also the assembly of many different raw materials may be involved, we shall find that whilst many of the heavy engineering industries are concentrated upon the coalfields, in the case of the lighter types of engineering product the existence of a market for the goods, or the availability of good transport facilities, may exercise as much control over the location of the industry as do the sources of raw materials. Moreover, as with the primary iron and steel producers, there are many examples of engineering industries the location of which is inexplicable in terms of presentday geographical and economic circumstances; we must often delve into the past to discover the location factors involved.

## The tinplate and allied industries[1]

Since the tinplate industry has changed out of all recognition since the 1930s most of what follows must now be regarded as historical geography; but a brief outline of the main features of the industry up to 1939 is necessary for the complete understanding of the subsequent developments.

The art of giving a coating of some non-ferrous metal to a thin sheet of iron, in order to preserve it, was first practised in Bohemia about the fourteenth century. The metal used was tin and the sheets thus became known as 'tin-plates'. Subsequently the metals zinc and lead have also been employed for the same purpose, giving rise to the trade names 'galvanised sheets' (coated with zinc) and 'terne plates' (coated with a mixture of tin and lead).[2] Recent developments include the use of chromium and aluminium as coating materials.

The first successful attempt to make tinplate in Britain took place in 1720 at Pontypool, where a small iron industry already existed, and a good water supply was available for working the hammers which produced the flat plates, and for washing the plates before tinning. From this small beginning grew the great industry in South Wales. Its growth was aided by two subsequent events: first the invention in 1728 of a method of rolling plates (a much quicker and more efficient process than hammering), and secondly the substitution of coal for charcoal in the iron smelting industry, permitting a much greater output. By the end of the eighteenth century a dozen works were producing tinplate, and our imports of that commodity had been replaced by a growing export trade. The industry spread rapidly during the first half of the nineteenth century, especially in Monmouth-

1. See J. H. Jones, *The Tin-plate Industry*; Rider and Trueman, *South Wales*, Chapter 10; E. H. Brooke, *Monograph on the Tin-plate Works in Great Britain*, Swansea, 1932.
2. The name 'terne' reflects the fact that such plates are composed of *three* metals—iron, lead, and tin; but it may also be derived from the French *terne* = dull or tarnished, in view of the contrast with the brightness of tinplate.

shire, Glamorgan, Gloucestershire, and Staffordshire (the last two supplied with iron from the Forest of Dean). All the works, however, were subsidiary to pre-existing smelting works or forges which were favoured with abundant water supply.[1] The reasons for this early concentration in South Wales are not clear. Probably the chance selection of Pontypool as the first site for a tinplate works prompted other ironworks in the neighbourhood to adopt this profitable sideline as an outlet for their iron at a time when the iron industry was not very flourishing; the nearness of South Wales to the Cornish tin supplies may also have given that area an advantage. In addition, the momentum derived from an early start sufficed to maintain the supremacy of South Wales in the industry even when the methods of production were radically changed, while the inland position of Staffordshire, and the decline of the iron industry in the Forest of Dean, prevented the rise of those areas in competition with South Wales. In 1850 thirty-five tinplate works existed, twenty-two of which were in South Wales. By 1875 the total had increased to seventy-seven, fifty-seven of which were in South Wales.

The last quarter of the nineteenth century witnessed vast changes in the nature and location of the tinplate industry. By the early 1870s Malayan tin had replaced the failing supplies from Cornwall, but this was of minor importance compared with the substitution of mild steel plates for wrought iron plates. Acid open-hearth steel suitable for rolling into tin plates was first produced at the Landore works (near Swansea) in 1875, and the cheapness of steel compared with puddled iron, together with its greater suitability—steel plates having a smoother surface which absorbed less tin soon resulted in its adoption in the tinplate works. But acid steel could only be made from imported pig iron, and in consequence steelworks, followed by tinplate mills, began to be set up in the neighbourhood of the ports of Llanelli, Swansea, and Briton Ferry, and the 'centre of gravity' of the tinplate industry in the vales of Swansea and Neath migrated downstream. Eight new steelworks, all associated with tinplate mills, were erected between 1875 and 1900. Many of the older tinplate works persisted for a considerable time; but the momentum possessed by an individual works usually a small, comparatively inexpensive unit—was not great, and in consequence migration was not difficult. This 'reshuffling' of the industry in the 'eighties, combined with the economic disaster produced by the American tariff of 1890, which almost cut off our chief market for tinplate, naturally resulted in a period of depression, but the first quarter of the present century witnessed a great expansion of the tinplate trade, and a remarkable concentration of the industry upon the Swansea Llanelli region.

Before considering the reasons for this development, let us further examine the nature and methods of the industry. Tinplates have many uses, and the expansion of the petroleum industry, and of canning industries of all kinds,

1. See H. C. Darby, 'Tin-plate migration in the Vale of Neath', *Geography*, **15**, 1929, 30 5.

has naturally been accompanied by a great increase in the production of the tinplates from which the containers are made. Until the development of plates coated with lacquer, now widely used, tinplate made the only metal container capable of being hermetically sealed; and it is perfectly safe for the canning of vegetables, fruit, fish, meat, and every other kind of perishable article. It is interesting to note the changing markets for tinplate. So long as it was mainly used for containers for fruit, fish, meat, and mineral oil the countries producing those commodities were the chief buyers of tinplate. With the increase in world output of mineral oil, the greater part is bulk handled, but petrol cans still dominate in remoter developing countries. Elsewhere more and more commodities are canned—beer for example—and Britain's great markets now are her European neighbours not producing their own (the Scandinavian countries, Spain and Portugal, Greece) together with South and South-West Africa, Argentina, Hong Kong, and even USA; but the list and the quantities vary widely from year to year (see p. 423).

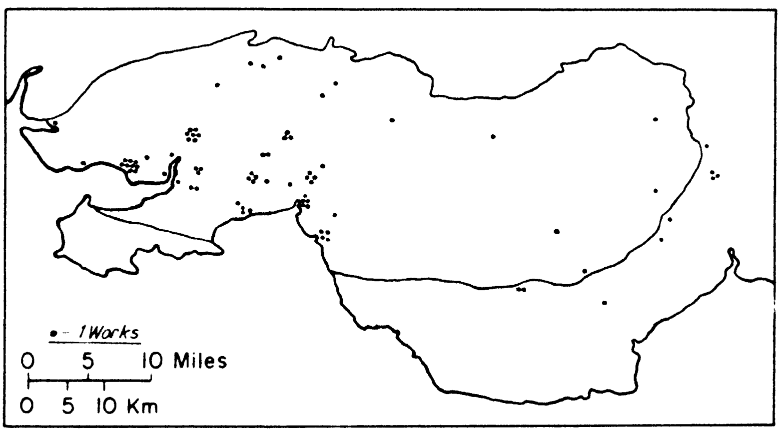



FIG. 176. Tinplate works in South Wales, 1932

Until the introduction at Ebbw Vale, and more recently at Margam, of the continuous hot-strip process, tinplates were produced by rolling out steel bars into thin sheets 0.25 to 0.5 mm (0.01 to 0.02 in) in thickness and cutting to the required sizes. These 'black plates' were then pickled in acid to remove the surface scum of oxide, heated again ('annealed') and re-rolled to produce a smooth, shiny surface, pickled again and then passed through a bath of molten tin. Coal-fired furnaces were used for heating the bars and for the annealing process, and often anthracite was used for maintaining the heat of the tin bath.

The advantages of the South Wales area as a whole for the production of tinplates were fairly obvious from the start. We have further seen how the industry, following the construction of the coastal steel mills, migrated

downstream to Swansea and Llanelli. The subsequent dominance of this area, however, was probably due to the coincidence of local fuel, the proximity of the non-ferrous smelting and refining industries which provided a reservoir of skilled labour and a source of sulphuric acid, the good rail communications and the development of the port facilities of Swansea (e.g. Prince of Wales Dock, 1882).

The distribution of tinplate works in South Wales, before the advent of the vast new integrated works, is shown in Fig. 176. With the exception of a few near Newport, the largest and most important works were all located within a few miles of the coast in the Loughor, Tawe, and Neath valleys, or at the ports of Llanelli, Briton Ferry, Swansea, and Port Talbot.

The introduction of the hot-strip process, which uses a succession of rollers to produce a continuous run of steel sheet, which can be coiled and later rerolled and cut as required, has revolutionised the industry. First at Ebbw Vale in 1937, and after the war at Margam, with associated cold-rolling and tinning plants at Velindre, near Swansea, and Trostre, near Llanelli, the new methods have made it possible to produce a greater output of tinplate from two basic plants than from seventy of the old pack mills before the war. As a result, all the old mills have been closed. Seldom can a single technical development have had such a catastrophic effect. Almost the entire national output of tinplate—which in the 1960s stood at a higher level than ever before—now comes from Ebbw Vale and the Margam–Velindre–Trostre complex. A further technological development has been the introduction of electrolytic tinning in place of the old hot-dip method; and almost 90 per cent of the output is now produced in this way.

Isolated centres of the old tinplate industry in Britain were Lydney, Gloucestershire, Stourport, Worcestershire—the last witnesses of the former prosperity of the trade in the Forest of Dean and around the Black Country—and Mold, Flintshire. The last-named centre owed its existence largely to its proximity to the port of Liverpool (which is the chief tin smelting centre in the country), and to the Brymbo steelworks.

Black plates (thin steel sheets without the coating of tin) form the basis of the enamelled hollow-ware industry, which has spread rapidly in South Staffordshire and in other parts of Britain. They are also exported either for this purpose, or for conversion into tinplates by certain countries which, although they can perform the tinning operation, cannot, or do not, produce the required quality of steel.

The manufacture of *galvanised sheets* was formerly associated with that of tinplate. When iron was the raw material South Staffordshire was the chief centre, but with the change-over to steel South Wales became the largest producer. The concentration in the Swansea district was natural enough, bearing in mind that the galvanising process was very similar to tinning, but it was favoured also by the fact that Swansea was the most important centre in the country for the smelting and refining of zinc. Just as the tinplate industry has undergone rationalisation, so has galvanising. In South

*The tinplate trade* (thousand long tons)

| | 1913 | 1921 | 1929 | 1931 | 1950 | 1956 | 1961 | 1969 |
|---|---|---|---|---|---|---|---|---|
| Production (Tin, Terne, and Black Plates) | 822 | 291 | 880 | 717 | 764 | 918 | 1077 | 1321 |
| Retained in Britain | 328 | 50 | 269 | 317 | 513 | 615 | 638 | 942 |
| Exported | 494 | 241 | 611 | 400 | 251 | 303 | 439 | 379 |

*Exports of tinplate* (thousand long tons)

| | 1913 | 1921 | 1929 | 1931 | 1950 | 1956 | 1962 | 1969 |
|---|---|---|---|---|---|---|---|---|
| Australia | 29 | 18 | 57 | 37 | 65 | 96 | 12 | 0 |
| New Zealand | | | | | 17 | 14 | 7 | 16 |
| India and Pakistan | 52 | 28 | 23 | 8 | 17 | 19 | 6 | 16 |
| Singapore and Malaysia | 17 | 12 | 27 | 14 | 8 | 17 | 15 | 6 |
| Hong Kong | | | | | | 5 | 12 | 24 |
| Canada | 10 | 3 | 28 | 37 | * | * | * | 0 |
| British W. Indies | | | | | | * | 5 | 9 |
| Other Commonwealth | | | | | | 18 | 20 | 28 |
| South and SW Africa | | | | | 19 | 1 | 53 | 18 |
| Argentina | 19 | 4 | 27 | 17 | 33 | 38 | 37 | 33 |
| Brazil | 14 | 2 | 22 | 18 | 3 | * | 7 | 6 |
| Japan | 28 | 22 | 32 | 22 | * | * | * | 0 |
| China | 15 | 8 | 20 | 16 | * | * | * | 2 |
| Sweden | | | | | | 12 | 22 | 23 |
| Norway | 25 | 5 | 17 | 9 | * | 3 | 18 | 5 |
| Denmark | | | | | 8 | 3 | 18 | 17 |
| Netherlands | 43 | 20 | 44 | 37 | 4 | 8 | 17 | 0 |
| Spain | 12 | 9 | 28 | 19 | * | 16 | 32 | 36 |
| Portugal | 14 | 4 | 18 | 19 | * | 3 | 17 | 19 |
| Italy | | | | | | 4 | 29 | 9 |
| Greece | | | | | | – | 12 | 9 |
| United States | | | | | | · | 36 | 42 |
| Total | 494 | 241 | 611 | 400 | 251 | 303 | 456 | 379 |
| Total (metric tons) | 502 | 245 | 621 | 406 | 255 | 308 | 463 | 385 |

Under 3000 tons. 1 long ton (2240 lb) 1.016 metric ton.

Wales the process is now undertaken at the great integrated works at Ebbw Vale and Port Talbot, and also at Gorseinon, which is one of the few remaining independent steelworks (cf. p. 408). One Black Country works survives, at Wolverhampton, whilst the trade in North Wales, formerly favoured by the proximity of the Flintshire zinc mines and carried on at

Mold, is now confined to the great steelworks at Shotton on Deeside. In Scotland two plants in the Motherwell area (one of them the integrated works at Ravenscraig) also produce galvanised sheets.

A coating of zinc protects the steel sheets from corrosion, and galvanised sheets, usually corrugated, are extensively employed for roofing and fencing in tropical countries. Popularly known as 'corrugated iron', they are far more durable than wood, and unaffected by insects. They do, however, rust through quickly under tropical conditions and corrugated asbestos and aluminium are often preferred. Galvanised sheets are also employed to an increasing extent for cisterns and tanks. The production of galvanised sheets is about a quarter that of tinplates. The exports are somewhat more restricted in their distribution than is the case with tinplates, and much of the tonnage is destined for Commonwealth countries.

The galvanising of finished steel products (e.g. tanks, cisterns, dustbins) is associated with the engineering industry rather than with steel making, and the most important area is the Black Country.

Finally, in recent years two new methods of coating thin steel sheets with non-ferrous metals have been developed. At Trostre an alternative for tinplate is now made, using electrolytically deposited chromium and chromium oxide in place of tin; it is a Japanese invention and is known as Hi-Top; it takes a lacquer coating better than tinplate. At Shotton, plant is being erected to use a process of coating steel sheet with aluminium powder; the market for such a product will be the manufacture of motor-vehicle silencers and other articles where corrosion resistance at high temperatures is required.

## Shipbuilding

The shipbuilding industry, like the iron industry, has undergone revolutionary changes in its geographical distribution during the last two centuries. The changes have been essentially due to alterations in the nature, and thus the distribution, of the raw materials employed, and to technical progress. The requirements of shipbuilding are two:

1. A navigable sheltered waterway, as near to the sea as possible, in which the vessels can be launched.
2. An easily available supply of the appropriate building materials.

When ships were constructed almost entirely of wood, the presence of fairly good timber supplies in many parts of Britain enabled the industry to be carried on at a large number of small estuaries and harbours all round the coasts, and the ease of import of timber permitted this to survive long after the local supplies were exhausted. The Thames below London and the Tyne were two of the most important centres, and such places as Inverness, Dundee, Whitby, Hull, Bristol, and Newport turned out many of those vessels—merchantment, whalers, and ships of war—which helped to lay the

foundations of the British Empire. The substitution, during the second half of the last century, of iron, and later steel, as the basis of the shipbuilding industry was naturally followed by the gradual decline of all those centres which were remote from the iron and steel-producing regions, and the increased importance of those estuaries, such as the Tyne, Tees, and Clyde, which were in close proximity to such regions, and which could accommodate vessels of ever increasing size.

Anything like a detailed history of the shipbuilding industry is impossible here;[1] we can only indicate in broad outline the general trend of events during the past century or so. The principal features may be outlined as follows:

## Raw materials

Until about 1850 most ships were built of wood and were of quite small size – in 1815 the average size of the vessels in the British Merchant Fleet was 100 tons, and in 1855 the largest vessel in the world, the Cunard *Persia*, was only 3600 tons. The first iron vessel was launched in 1812, and the first iron vessel to cross the Atlantic (the *Sirius*) did so in 1838, but even in 1850 only 9 per cent of the new tonnage constructed was of iron. By the 1870s, however, iron was fast supplanting wood as the standard material, and in 1880 under 4 per cent of the new tonnage was of wood. From this point, however, steel began to usurp the position which iron had gained and its success by reason of its greater tensile strength per unit of weight was assured. By 1900 the new tonnage built of iron had fallen to nil.

The use of iron and later of steel in shipbuilding proved the salvation of the British industry, for our home timber supplies had been reduced almost to nothing, and the repeal of the Navigation Acts in 1849, by throwing open our commerce to the world's ships, would have put British building at the mercy of other countries, such as the USA, where abundant timber was available near tide water. The advantageous situation of our coal and iron supplies not only prevented any such catastrophe, but gave to the British industry a stimulus which maintained its world supremacy for the century that followed.

## Method of propulsion

Steam was first used as a method of propelling a ship in 1788, and the steamer *Sirius* crossed the Atlantic in 1838. By 1850, however, sailing vessels

1. A good short summary will be found in *Survey of Metal Industries*, pp. 363–9. Greater detail is given in D. Pollock, *Shipbuilding Industry*, Methuen, 1905. Some splendid histories of individual shipbuilding firms are available; see for example K. C. Barnaby, *100 years of Specialised Shipbuilding and Engineering* (Thorneycrofts), Hutchinson, 1964; Sir A. Grant, *Steel and Ships: the history of John Brown's*, London, Joseph, 1950; *Two hundred and fifty years of shipbuilding by the Scotts at Greenock*, Glasgow, 1961.

still represented 95 per cent of the total British tonnage, and not until the 1880s did the sail tonnage begin to drop below the tonnage under steam, since when its decline has been very rapid. The earliest steamships were propelled by paddle wheels. After 1850, though many paddle steamers continued to be built, the screw propeller became the more general method. Great advances were made in the efficiency of the steam engines by the employment of the multiple expansion principle; but the greatest revolution came at the end of the century with the introduction in 1897, by Sir Charles Parsons, of Newcastle, of the steam turbine. In recent decades oil has almost completely replaced coal as the fuel for steamships. Oil has, of course, the advantages of being less bulky, more easily stored, cleaner and quicker to load, and requiring less manpower at the boilers. Great strides have been made also, within the last few decades, in the adaptation of the Diesel engine, consuming heavy oil, to marine propulsion, and the tonnage of motor ships launched annually in the United Kingdom is now far greater than that of steam driven vessels (see table opposite). In 1936 of a world total of over 65 million tons of shipping, coal-fired steamers represented 32 million tons, oil-fired steamers 20 million tons, and motor-driven vessels just over 12 million tons. By 1968, the world total had risen to 186 million tons, of which coal-fired steamers represented only 3 million, oil-fired steamers 71 million, and motor-ships 120 million tons. In 1968, only 1.6 per cent of the world's shipping was using coal, as against 45 per cent in 1939 and 97 per cent in 1914. In 1952, for the first time since the introduction of steam, not a single coal-fired ship was launched from British yards. The consequences for the British coal trade and tramp shipping of this wholesale abandonment of coal have been profound.

## New types of vessel

The development of the giant passenger liner, of the large mixed-traffic vessel (usually with refrigerated cargo space), and more recently of the 'supertanker', of specialised vessels for the carriage of liquefied natural gas, of bulk carriers for ore and grain traffic, and of the 'container' ship, have added new problems for the shipbuilders to solve, and great advances in the techniques of construction have been made, especially since the Second World War.[1] Ships are now being built of dimensions that would have been thought utterly impossible only twenty-five years ago. Whereas, for example, the standard oil tanker of the 1930s was a vessel of about 10 000 to 12 000 tons, and the Americans built several hundreds of 16 000-ton tankers during the war, tankers of 24 000 tons made their appearance in the late 1940s, only to be superseded a few years later by 'supertankers' of 30–40 000, and then in the 1960s by still larger vessels of over 100 000 tons

1. See S. H. Beaver, 'Ships and shipping: the geographical consequences of technological progress', *Geography*, **62**, 1967, 133–56.

*United Kingdom shipbuilding: tonnage launched (excluding warships)* (thousand tons)

| CLASS | 1913 | 1921 | 1929 | 1933 | 1937 | 1942[1] | 1949 | 1952 | 1961 | 1968 |
|---|---|---|---|---|---|---|---|---|---|---|
| Steamers: | | | | | | | | | | |
| Coal fired | 1911 | * | 750 | 78 | 307 | * | 23 | 0 | 0 | 0 |
| Oil fired | 0 | * | 306 | 5 | 220 | * | 413 | 440 | 572 | 12 |
| Total Steamers | 1911 | 1430 | 1056 | 83 | 527 | 814 | 436 | 440 | 572 | 12 |
| Motor Ships | 8 | 102 | 464 | 48 | 388 | 448 | 832 | 854 | 682 | 886 |
| Barges, etc. | 13 | 6 | 3 | 2 | 5 | 13 | 0 | 8 | 2 | 0 |
| Total | 1932 | 1538 | 1523 | 133 | 921 | 1276 | 1267 | 1302 | 1256 | 898 |
| Tankers | 238 | 251 | 175 | 3 | 144 | 312 | 434 | 370 | 393 | 81 |

[1] War peak year  * Not available.

and indeed up to 350 000 tons. A few such vessels can quickly alter the statistical picture of world's shipping. In the late 1930s oil-tankers represented about 15 per cent of the world's mercantile marine; by 1952 this had risen to 22 per cent, and by 1968 the 4540 tankers then afloat totalled 72.2 million tons, or 39 per cent of the world's fleet. Similarly with the bulk carriers that have largely replaced the old-fashioned tramp ships of a generation ago: ships of between 35 000 and 100 000 tons are now being used for iron ore traffic; they can often be employed for grain or other bulk cargoes as well, and for oil.

The day of the outsized passenger liner is over, largely owing to the competition of air travel (cf. p. 714); the *Canberra* of 1960 was only 45 000 tons; the 80 000 ton *Queens* have gone, and their replacement is a vessel of only 65 000 tons. Even the shape of the big passenger ships has altered. At the other end of the scale the small ferryboat is being replaced by the hovercraft, based on an entirely different principle and capable of two or three times the speed of the conventional ship.

## Geographical distribution of shipbuilding

The increase in the size of ships and in the bulk of the machinery and component parts of which they are built has greatly accentuated the localisation of the shipbuilding industry upon the largest estuaries adjacent to the steel-producing regions. Because the shipbuilding industry is essentially an *assembly* industry, however (cf. motor vehicles, p. 444), it is possible for many outlying centres to survive, albeit in most cases by specialising in certain types of craft. Broadly speaking the industry falls into four groups: (1) the major estuaries that build most of the tonnage and all the large

vessels—Clyde, Tyne, Wear, Tees, Mersey, Belfast Lough, with Barrow in a non-estuarine situation; (2) the minor estuarine and coastal centres, in general capable of building small general-purpose cargo ships and coasters —such as Dundee, Grangemouth, Aberdeen, Ardrossan and Lowestoft; (3) the 'small-ship' centres, including the fishing-boat builders of the Humber group and the yacht and hovercraft centres on the south coast— Southampton and Portsmouth; (4) the Royal Dockyards, sited for strategic reasons, sometimes very long ago, on certain tidal waters in southern England.

In 1958 the total employment in shipbuilding, ship repairing and marine engineering was 275 000 (including 37 000 in marine engineering), but this figure had fallen to 202 000 at the Census of Production in 1963, including 39 000 in marine engineering. The loss of employment in shipbuilding and repairing is thus of the order of 70 000 in fifteen years.

The relative importance of the various districts is shown in the table below. But an important word of caution is necessary in interpreting the recent figures; sharp fluctuations from year to year have always occurred, for an individual ship takes a long time to build and only appears in the statistics on its launching. A yard may nowadays launch nothing for a whole year and then produce a 100 000-ton tanker—so one must not assume from the table that in 1968 the Wear had unbounded prosperity whilst Barrow was in the depths of depression.

*Shipbuilding: tonnage launched*[1] *(excluding warships)*.
Gross tonnage (thousands)

| AREA | 1913 | 1921 | 1929 | 1933 | 1937 | 1950 | 1962 | 1965 | 1968 | 1968 No of ships |
|---|---|---|---|---|---|---|---|---|---|---|
| Clyde | 685 | 505 | 532 | 49 | 337 | 438 | 363 | 316 | 189 | *25* |
| Tyne | 366 | 355 | 272 | 11 | 102 | 206 | 197 | 159 | 120 | *13* |
| Wear | 300 | 144 | 245 | 12 | 156 | 191 | 214 | 253 | 238 | *18* |
| Tees | 308 | 164 | 92 | 15 | 83 | 141 | 51 | 44 | 171 | *7* |
| Belfast | 129 | 93 | 144 | 14 | 74 | 131 | 89 | 130 | 98 | *2* |
| Mersey | 34 | 51 | 55 | 3 | 34 | 67 | 45 | 41 | 25 | *2* |
| Dundee | 18 | 17 | 17 | 7 | 21 | 19 | 18 | 13 | 4 | *1* |
| Humber | 49 | 31 | 27 | 8 | 16 | 20 | 12 | 14 | 13 | *27* |
| Barrow | 2 | 64 | 20 | 0 | 48 | 60 | 33 | 62 | 0 | *0* |
| Leith | 19 | 17 | 32 | 7 | 36 | 30 | 32 | 17 | 18 | *5* |
| Other Districts | 22 | 97 | 87 | 7 | 14 | 22 | 19 | 24 | 22 | *34* |
| Total | 1932 | 1538 | 1523 | 133 | 921 | 1325 | 1073 | 1073 | 898 | *134*[2] |

[1] Only vessels of 100 tons and over are included in this table and the previous one (*Lloyd's Register of Shipbuilding*—annual summaries).
[2] Of these 134 ships only one, of 12 000 tons, built on the Clyde, was a *steamship*.

## The northeast coast

The northeast coast includes the estuaries of the Tyne, Wear and Tees. On the Tyne the major yards are at Walker, Wallsend and Willington Quay on the north bank and Hebburn, Jarrow and South Shields on the south bank. Much of the industry is now in the Swan Hunter group. Ships of all kinds have been launched from these yards, though in the past the emphasis was on tramp steamers, colliers and warships (from Vickers-Armstrong) rather than on passenger liners. The emphasis now is on tankers, bulk carriers and container ships. On the Wear at Sunderland there are five yards, four on the riverside and one, unique in the country, that launches direct into the North Sea. The modern specialities, as on the Tyne, are large tankers, bulk carriers and cargo liners. On the Tees there are two centres, on the estuary itself at Haverton Hill and South Bank, and at West Hartlepool just north of the river mouth. Again, the major output is of freight-carrying vessels of various kinds.

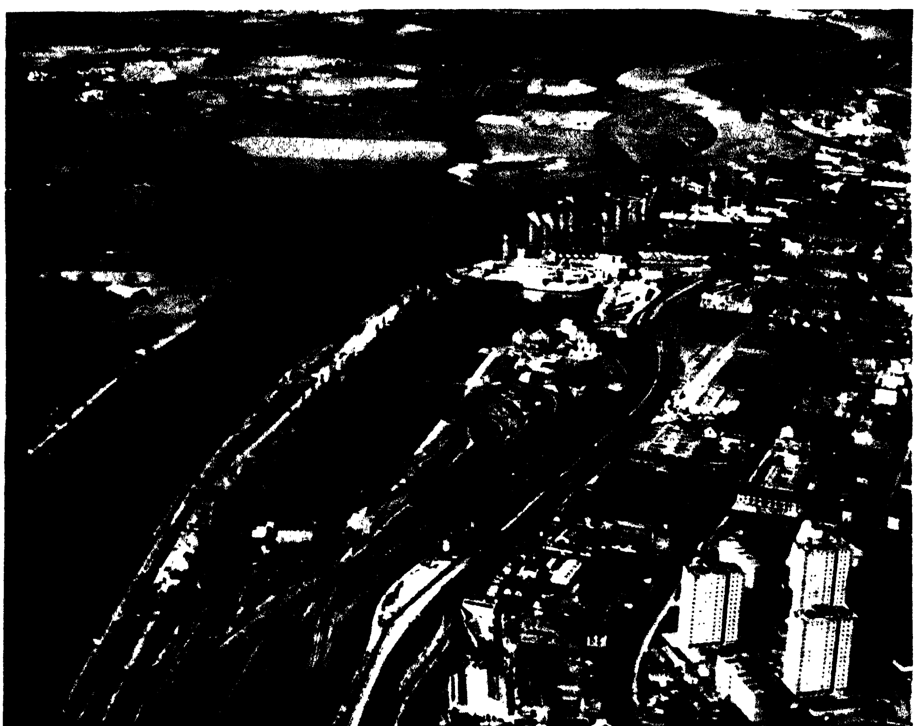


PLATE 21. Shipyards at Clydebank

John Brown's yards (marked by the T-cranes) in which the *Queens* were launched; the building slip is oriented towards the mouth of the river Cart (extreme left) which effectively increases the width of the Clyde at this point.

### The Clyde

The Clyde was never as important as the Tyne in the days of sailing ships. Its rise is more recent: it was in 1812 that Bell's *Comet* was launched by John Wood at Port Glasgow, but most of the growth is post-1840. It was not an ideal waterway for shipping—at the end of the eighteenth century no boats drawing more than 1.5 metres could reach Glasgow; only by persistent dredging has it been improved and maintained. Indeed, for 19 kilometres below Glasgow the Clyde has been described as 'artificial as the Suez Canal'. Of the twenty shipbuilding firms formerly located on a 32 kilometre (20-mile) stretch of the river below Glasgow a number have been driven out of business by the economic stresses of the last decade; Upper Clyde Shipbuilders have incorporated most of those at the Glasgow end, with yards at Govan on the south bank and at Scotstoun and Clydebank on the north bank, whilst the Scott Lithgow group controls the yards at Port Glasgow and Greenock; the Denny yard at Dumbarton, that built many cross-channel steamers, closed in 1963. Both naval and merchant vessels up to the largest pre-1940 sizes were constructed—including in the interwar period the battleship *Vanguard* and the two *Queens*. Since the war the fortunes of the Clyde have declined somewhat, though the *Queen Elizabeth II* was launched from the same yard as her predecessors in 1968. The river is not ideal for launching vessels of exceptional size (and the *Queens* berth at John Brown's yard at Clydebank is carefully aligned so as to project the launched vessel into the mouth of the river Cart), and Clyde participation in giant tanker building is likely to be at the Port Glasgow end.

The northeast coast and the Clyde together have been responsible since the First World War for about 75 per cent of the British output of ships, and with the increasing size of bulk carriers and tankers this percentage is likely to rise rather than fall, for it is in these estuaries that there is the greatest capacity for launching large vessels. Indeed in 1968 the percentage was 80. The other areas are much smaller, both in extent and in output.

### Belfast

Although not backed by a great iron and steel producing region, the head of the sheltered Belfast Lough, by the estuary of the Lagan, has remained an important shipbuilding centre by reason of the ease of import of the raw and semifinished materials required. Both western Scotland and the English northwest are capable of supplying Belfast with steel, and other materials can be imported via other British ports or directly from abroad. Belfast-built liners, cargo ships and tankers are to be found on most of the world's shipping routes. Harland & Wolff Ltd have extensive shipyards and engineering shops; the largest vessel launched to date is a 250 000-ton tanker for Esso in 1970. In addition to manufacturing all types of propelling machinery Belfast engineers have materially aided the development of

the Diesel engine for nautical purposes. Shipbuilding employs nearly 8000 people at Belfast, and marine engineering another 4000.

### Birkenhead

At Tranmere, on the southern side of Birkenhead, are the large yards of Cammell Laird, builders of warships, cargo ships, tankers and passenger liners.

### Barrow

Shipbuilding was not important here until the local iron ores came to be used in large quantities for steel-making. The first vessel was launched in 1873. The greater part of the industry is under the control of Vickers. Both naval and merchant vessels have been built and Barrow has a distinguished list of liners and tankers to its credit, including the first 100 000-ton tanker launched from a British yard. There has also, for no particular geographical reason, been a specialisation in the building of submarines.

### Minor Scottish centres

Aberdeen, at the beginning of the last century, was the chief shipbuilding port in all Scotland, and later on in the 1850s and 60s many famous 'tea clippers' were launched from its yards for service between Britain and China. Subsequently it has come to specialise in vessels for its own particular trade trawlers, whalers and other fishing craft. Also on the Scottish east coast, Dundee, Grangemouth and Leith build small cargo ships, and there are small yards at Troon and Ardrossan on the Ayrshire coast.

### The English east coast

A number of ports on the east coast and its inland waterways have small shipyards, but the vessels constructed are mostly small and of specialised character. The Humber region offers a remarkable example of an industry carried on solely as a result of momentum gathered in past years. Always an important fishing centre, this estuary naturally developed the building of all kinds of fishing boats, and the ease of access, by rail and canal, to the Sheffield district and by sea or by rail to the Tees-side steelworks, together with the old-established import trade in timber, have resulted in a continuation of the industry. Hull itself, Beverley on the river Hull, Selby on the Ouse, together with Knottingley, Goole and Thorne, have yards capable of building trawlers and drifters and other small craft, for which various firms in Hull or elsewhere build the engines. At some of the yards the vessels are launched sideways into the narrow river on which the yard stands. The Humber retains its position in the front rank of fishing craft construction centres (see Fig. 257).

Further south, a somewhat similar specialisation in fishing and small coastal craft is to be found at Lowestoft.

### Minor centres

A number of other ports have small shipbuilding industries, but the vessels constructed are mostly small; vessels of under 100 tons are not included, except for certain purposes, in Lloyd's Register, but as an industry the building of small craft is of increasing importance. The motor cruiser or yacht or even a small boat, has now become a 'status symbol'. Southampton, Cowes and Portsmouth specialise in yachts, motor boats and certain types of small naval craft, and more recently in hovercraft. On the North Devon coast a yard at Appledore specialises in tugs, dredgers, trawlers and the like.

The Thames no longer builds ships (though a small yard remains at Faversham on the Medway). But for a long period it was one of the major centres. The Blackwall yard, where the Orient Line had its origin, was founded in 1612, and a number of famous ships, including the *Warrior* (the first ironclad, built at Canning Town 1859) and the *Great Eastern* (built at Millwall in 1855) have been launched from Thames-side yards. During the Victorian period some of the most prosperous firms in the country were located here; but the distance from the major steel-producing areas has driven them all out of business or to other localities, and all that remains is the extensive repair service referred to below. The surprising thing is that the industry managed to overcome the economic difficulties involved for so long a period: the battleship *Thunderer*, the last big vessel to be launched, was only completed in 1911.

In the Irish Republic there is a shipyard, state subsidised like the nearby steel industry, at Cork.

Attention must finally be called to the shipbuilding activities of the Royal Dockyards. Although a considerable proportion of the naval requirements is ordered from public companies, a good deal of warship construction is, or was, carried out at Devonport, Chatham, and Portsmouth. All these places occupy heavily fortified situations where large expanses of tidal water are available for the 'housing' of the British fleet. In many cases only the hulls of the new vessels are erected at the dockyard, the machinery being supplied by public firms of marine engineers.

## Ship repairing

In addition to the actual building of new ships, the repairing and overhauling of existing vessels is an industry of considerable importance. In its distribution, however, this industry is much more widespread than shipbuilding. The chief necessity is a dry dock or some other means of raising the ship out of the water so that access to the hull may be obtained (see Fig. 177). It should be remembered, however, that many repairs may be effected without this preliminary procedure and that ordinary building yards may be used for repair work. Since it is obviously most economical to repair a ship on the termination of a voyage, during which the need for

repair becomes apparent, the great ports of the country, as well as the shipbuilding areas, will share in the repairing industry; for the amount of material necessary to effect the repairs will not be large and may be of very diverse nature.

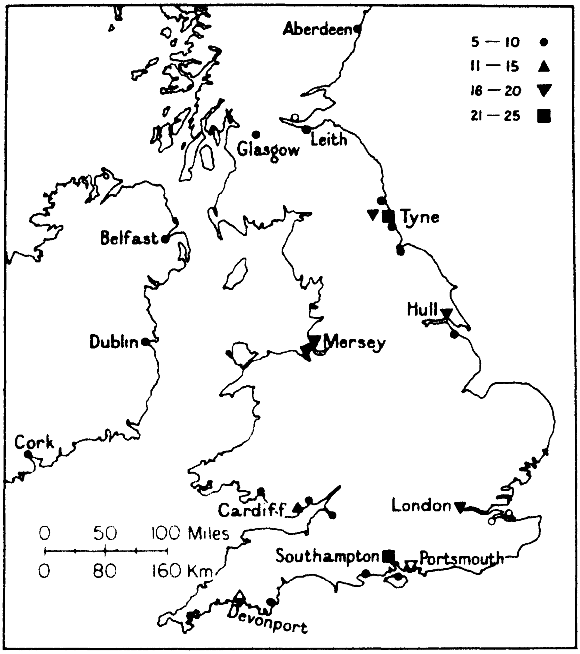



FIG. 177. Facilities for ship-repairing in Britain: number of dry docks and slipways, 1951. Belfast now has twelve

The symbols in outline are naval dockyards. In addition to the ports shown on the map, forty-nine other ports have ship-repairing facilities

Whilst the Tyne, as judged by the number of dry docks, etc., dominates the industry, dealing with all classes of cargo ships, liners, and tankers, the ports of London, Southampton, Liverpool, and Belfast have extensive facilities, largely controlled by the great shipbuilding firms,[1] for the repair of the large liners and other vessels which visit them. The Clyde is not nearly as important for repairing as for building—although more repairing is done than is suggested by Fig. 177, many building yards, when not engaged in new construction, being used for this type of work.

The advent of the giant tanker and the increasing size of bulk carriers have created problems for the ship repairing industry as they have for the shipbuilders. New dry docks have had to be constructed in order to cope

1. Harland and Wolff, for example, own extensive yards at Liverpool and Southampton and control the repair yards of the Port of London Authority.

with the overhaul of such vessels; such provision has already been made at Birkenhead, London, Newcastle (Hebburn) and Glasgow, whilst the deep water of the Fal estuary has encouraged a firm at Falmouth to offer similar facilities, and in Belfast a new dry dock capable of taking vessels of up to 200 000 tons has been built.

## Marine engineering

Although the chief new materials necessary for the shipbuilding industry are steel plates and girders, castings, forgings, tubes and pipes, i.e. the 'heavy' products of the iron- and steelworks, numerous other items enter into the construction of a ship, and there is an increasing tendency to employ aluminium and alloys thereof in the fabrication of the superstructures. A large amount of finished machinery such as winches and pumps is required, and large supplies of furnishing materials, joinery, paint, rope, and nautical instruments are also necessary. Many subsidiary industries are thus involved. Chief of these is marine engineering the construction of the boilers, turbines, and driving gear for all kinds of vessels. The marine engineering industry, dealing as it does in very bulky, though valuable, pieces of machinery, must of necessity be located in close proximity to the shipyards. In many cases the shipbuilders control their own marine engineering works. The chief centres of the industry are the Clyde (Glasgow, Clydebank and Greenock) and the northeast coast (Newcastle and Sunderland). Employment in the marine engineering industry recorded by the 1948 Census of Production amounted to 54 000, of which over 21 000 were in Scotland and nearly 18 000 on the northeast coast. The 1963 Census of Production recorded 39 000, but this figure is for establishments dealing solely in marine engineering and does not include those employed in the marine engineering sections of shipbuilding firms.

### Shipbuilding—Britain and the World

The shipbuilding industry has long been described as a 'trade barometer', as it reflects, perhaps more faithfully than any other trade, the general state of the world's commercial activity. It also reflects in a very remarkable way the incidence of wars, as Fig. 178 shows. At the same time it is the key to the prosperity, or otherwise, of a large number of subsidiary industries. Quite apart from the steel industry, so many other trades are involved that a slackening of the demand for new ships may be followed by a depression, the repercussions of which are felt throughout the country. The shipyards suffer most, however. The iron- and steelworks may have other products, such as boiler plates, girders, and rails, to which they can turn their attention, and the engineering shops may obtain orders for other types of machinery, but a shipyard has difficulty in changing.

The British shipbuilding industry faces many problems. The cream of the world's passenger traffic now goes by air and the days of the great passenger liner are probably over though there is an apparently elastic demand for holiday cruises from which many of the shipping companies derive their main profitable revenue. Whatever the reason may be—high labour costs, restrictive practices, out-of-date methods and equipment, design, tardiness of delivery, unattractive financial terms are all named—Britain has lost the dominating position formerly held in shipbuilding.

The following table lists the output of the world's chief shipbuilding countries in certain selected years, the selection emphasising the booms and depressions. Complete figures for the war peak year, 1943, are not available, but the world total in that year reached the staggering figure of 13 885 000 tons, largely owing to the enormous tonnage launched in the USA. In that same year the British output represented a mere 8 per cent of the world total. In 1958 Britain fell behind both Japan and West Germany in ships launched. Japan continues to lead the world since 1956, and in 1968 British launchings represented only 5 per cent of the world total. Indeed, since 1958 Britain has been a net *importer* of ships, and in 1967 no less than fourteen countries were building ships for British owners!

*World's shipbuilding (excluding warships) gross tonnage* (thousands)

| COUNTRY | 1913 | 1919 | 1926 | 1930 | 1933 | 1937 | 1957 | 1962 | 1968 |
|---|---|---|---|---|---|---|---|---|---|
| United Kingdom | 1 932 | 1 620 | 639 | 1 478 | 133 | 921 | 1 414 | 1 073 | 916 |
| Germany | 465 | * | 180 | 245 | 42 | 435 | 1 231 | 1 010 | 1 344 |
| France | 176 | 32 | 121 | 101 | 34 | 26 | 428 | 481 | 502 |
| Netherlands | 104 | 137 | 94 | 153 | 36 | 183 | 476 | 418 | 293 |
| Italy | 40 | 83 | 20 | 87 | 17 | 22 | 485 | 348 | 497 |
| USA | 276 | 4 075 | 150 | 247 | 11 | 239 | 359 | 449 | 416 |
| Japan | 64 | 612 | 52 | 151 | 74 | 451 | 1 511 | 2 183 | 8 644 |
| Other countries | 265 | 585 | 218 | 427 | 141 | 433 | 2 597 | 2 413 | 4 312 |
| Total | 3 332 | 7 144 | 1 674 | 2 889 | 489 | 2 710 | 8 501 | 8 375 | 16 944 |
| Per cent by UK | 58 | 23 | 38 | 51 | 27 | 34 | 17 | 13 | 5 |

* Figures not available.
In 1968 'other countries' include Sweden 996 and Norway 500

## Engineering

If the recent history of shipbuilding makes dismal reading, it is very much otherwise with the engineering industries. The term 'engineering' now covers a vast range of industries. Beginning during the Industrial Revolution with the making of engines and textile machines, it now embraces all kinds of machinery and the machine and hand tools with which to fashion them.

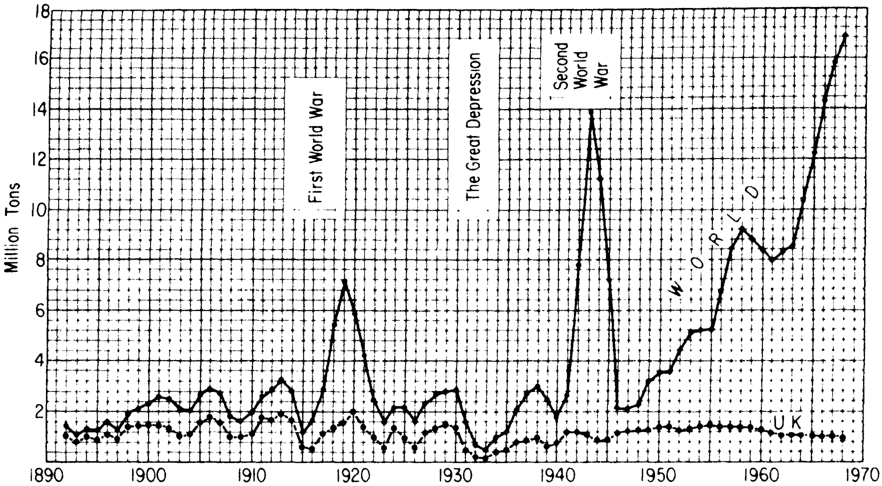



FIG. 178. Shipbuilding in the UK and the World, 1892–1968
In terms of tonnage launched, the UK figure has varied comparatively little in 75 years, but world output since the Second World War has expanded enormously, particularly in Japan

These fundamental branches have always been in large measure dependent on the iron and steel industry for their raw materials. During the twentieth century, however, other industries have arisen, concerned mainly with electrical apparatus of many kinds, from generators, motors and cables to radios and computers, the raw materials of which include non-ferrous metals, plastics and ceramics as well as iron and steel. In addition, there are the industries that produce self-propelled vehicles—locomotives, automobiles and aircraft; these are categorised separately in official statistics, but we can include them in this chapter since they also depend mainly on metallurgical industries for their raw materials.

The two following tables demonstrate the relative importance of the various branches.

*Employment in engineering, 1966* (thousands)

| | | | |
|---|---|---|---|
| Radio and electronics | 306 | Machine tools | 96 |
| Electrical machinery | 236 | Other machinery | 370 |
| Wires and cables | 67 | Other mechanical engineering | 253 |
| Telegraph and telephone apparatus | 96 | | |
| Other electrical goods | 215 | Total engineering | 2352 |
| Scientific and photographic instruments | 138 | Motor vehicles | 500 |
| Industrial plant and steelwork | 162 | Aircraft | 255 |
| Agricultural machinery | 38 | Locomotives | 36 |
| Textile machinery | 59 | Railway rolling stock | 42 |
| | | Motor cycles and pedal cycles | 26 |
| | | Total vehicles | 865 |

*Value of engineering products* (£ million)

| | 1960 | 1966 |
|---|---|---|
| Electrical machinery | 312 | 454 |
| Insulated wires and cables | 136 | 254 |
| Radio, radar and electronic capital equipment | 60 | 329 |
| Domestic electrical appliances | 130 | 157 |
| Other electrical goods (exc. radio) | 212 | 322 |
| Industrial plant and fabricated steelwork | 294 | 527 |
| Contractors' plant and quarrying machinery | 93 | 143 |
| Metal working machine tools | 112 | 167 |
| Mechanical handling equipment | 87 | 133 |
| Engineers' small tools | 65 | 92 |
| Industrial engines | 81 | 138 |
| Pumps and industrial valves | 93 | 144 |
| Textile machinery | 84 | 111 |
| Other machinery (not electrical) | 572 | 775 |

*Note* The overall increase of 60 per cent in the value of the engineering industry's output between 1960 and 1966 is of course in some measure due to inflation, but clearly some branches—the radio and electronic in particular—have expanded at far more than the average rate

The geographical principles underlying the distribution of the engineering industries have already been touched on (p. 418). It is probably true to say that there are few towns of any size in the country which have not either a foundry or some small factory making use of iron and steel. This being so, a rough classification of the engineering towns is necessary in order that we may better comprehend the distribution of the industry. Engineering towns in Britain may be divided into two distinct types:

(*a*) Those in which the engineering industry is preserved by reason of the local supplies of coal and iron; e.g. the towns of the coalfields. The particular branch of engineering involved will depend primarily on various local factors which we shall examine in detail later;
(*b*) Towns not situated on, or quite close to, the major coalfields and iron-producing centres. These towns may be further subdivided into two classes: (1) Those in which the presence of the engineering industry is due to some definite local demand for certain types of iron products. Under this heading come most of the engineering centres of eastern England, where the manufacture of agricultural implements is of quite early origin. (2) Those in which the engineering industry is of much more recent growth and is due either to the situation of the town with regard to railways—as, for example, former locomotive building towns of Swindon and Ashford (Kent)—or to the presence of large and increasing agglomerations of population which

can be drawn upon as a source of labour supply, e.g. Letchworth (Herts.), Luton, and Slough.

This classification cannot be regarded as comprehensive or exhaustive, but it may serve as a guide in our study of the engineering industry of Britain. The chief engineering provinces are seven in number. They may be briefly summarised as follows:

*Manchester and south Lancashire.* Textile machinery, constructional engineering, engines and locomotives, and electrical apparatus.
*Yorkshire, Nottinghamshire and Derbyshire coalfield.* Textile machinery (West Yorkshire), heavy engineering, locomotives; the special trades of Sheffield and the miscellaneous industries of Derbyshire and Nottinghamshire.

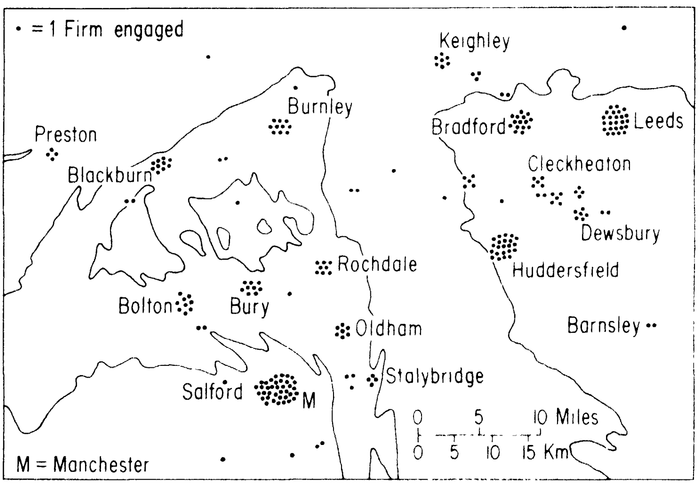



FIG. 179. The textile engineering industry of Lancashire and Yorkshire. Lines show boundaries of exposed Coal Measures. This map refers to the interwar period but the general distribution remains

*The northeast coast.* Marine engineering (see above), constructional engineering, locomotives.
*The Scottish Lowlands.* Marine engineering (see above), constructional engineering, heavy machinery, locomotives.
*The Black Country and Birmingham.* Heavy foundry and forge work, constructional engineering, miscellaneous trades of Birmingham.
*The smaller Midland coalfields.* Miscellaneous industries of North Staffordshire and Warwickshire.
*Southeastern Great Britain.* Scattered miscellaneous machinery industries and foundry products, especially agricultural and excavating machinery and locomotives.

Before we consider these provinces in greater detail certain rather specialised industries call for individual comment.

## Textile machinery

The manufacture of textile machinery is dominant, as one would expect, in the great textile working regions of southeast Lancashire (nearly two-thirds) and the West Riding (a fifth) (see Fig. 179), the only other centres of any importance lying within the regions of minor specialised textile production. The industry has been located here on both sides of the southern Pennines ever since the first machines for working cotton were invented (i.e. since the end of the eighteenth century), and the growth of the textile industries, together with the presence of coal and the proximity of the iron and steel districts of Yorkshire and the Midlands, have given it such a momentum, that it easily retains the premier position, which it has always held, supplying not only the manufacturers, but also, until comparatively recently, most of the other textile industries of the world. The map shows that nearly every important town in the textile manufacturing area of Lancashire and Yorkshire has one or more factories engaged in producing machinery for working cotton, wool, or the modern manmade fibres. Although the Lancashire towns confined themselves mainly to cotton-manufacturing machinery, and the West Riding towns to woollen and worsted machinery, a few firms in the towns where the two regions approach most closely (e.g. Huddersfield, Keighley, Rochdale, and Oldham) produced machinery for both industries; and firms making machinery for the newer textiles are to be found in both regions. Some of the larger firms turn out practically every machine which is used in the textile industries; others specialise in certain types of machine, or machines for special processes.

*Exports of textile machinery* (thousand long tons)

| COUNTRY | 1913 | AVERAGE 1921–25 | 1929 | 1933 | 1948 | 1962 | 1966 |
|---|---|---|---|---|---|---|---|
| USSR | 15.3 | 0.6 | 7.0 | 0.2 | – | 4.7 | 1.8 |
| France | 12.6 | 12.2 | 7.5 | 0.9 | 3.5 | 2.6 | 2.8 |
| Belgium | 10.3 | 5.8 | 7.5 | 1.6 | 4.0 | 1.5 | 1.8 |
| Germany | 13.9 | 2.7 | 5.1 | 1.6 | | 1.9 | 3.9 |
| Italy | 2.4 | 4.1 | 4.3 | 1.3 | 0.5 | 2.7 | 1.4 |
| China | 3.3 | 9.4 | 10.6 | 2.5 | 2.8 | — | 1.0 |
| Japan | 19.7 | 15.0 | 14.4 | 1.0 | | 1.4 | 0.5 |
| India | 50.3 | 49.1 | 38.2 | 24.9 | 23.0 | 16.5[2] | 23.3[2] |
| Brazil | 11.9 | 8.2 | 3.3 | 1.9 | 8.7 | 2.2 | 1.4 |
| Other countries | 38.3 | 28.3 | 78.6 | 20.6 | 17.5[1] | 44.5[3] | 46.2[4] |
| Total | 178.1 | 135.4 | 126.5 | 56.5 | 60.0 | 78.0 | 84.1 |
| Total (metric tons) | 180.9 | 137.6 | 128.5 | 57.4 | 60.9 | 79.2 | 85.4 |

[1] Includes Egypt, Argentina, Australia, and Canada.
[2] Includes Pakistan.
[3] Includes Australia (3.1), S. Africa (3.0), USA (2.8).
[4] Includes USA (6.2), S. Africa (3.7), Australia (2.5).

Great prosperity was enjoyed in Lancashire while the factories were building machinery for the growing cotton industries of Japan, China, and India, but the excess of productive capacity thus created caused a slump. Foreign firms even bought secondhand machinery from Lancashire's closed mills.

In the textile machinery industry as a whole, employment declined from 70 000 in 1921 to 60 000 in 1924, and 48 000 at the Census of Production in 1930. The revival revealed by the 1948 Census of Production (67 000) was largely due to the manufacture of machinery for working the newer textile fibres (see Chapter 21), but at the 1963 Census of Production the figure was down to 48 000 again.

Of the other localities where textile machinery is made, the chief are Nottingham and Leicester, which between them share the bulk of the trade in hosiery machinery. Nottingham, in addition, is supreme in the manufacture of lace-making machinery. Macclesfield occupies a similar position with regard to silk machinery; and Dundee makes most of the machinery used in the jute and hemp trades. A few other scattered centres in Scotland make various kinds of textile machinery, e.g. Hawick and Galashiels (woollen), Paisley and Glasgow (cotton). Belfast supplies textile machinery for the working of flax, hemp, manmade fibres, and wool to most parts of the world. Much of the produce of the textile machinery industry, as suggested above, is destined for export.

The 1913 export figure has never again been attained. The actual amounts exported to individual countries may fluctuate considerably from year to year—but it is still true that India (now India and Pakistan) is by far our best customer. The Far Eastern market has seriously declined, but our near European neighbours can still be relied upon to take textile machinery, whilst growing textile industries in other parts of the world are buying British machines.

## Locomotive building

The locomotive-building industry of Britain, although of long standing (some of the firms are over 100 years old), was distributed in an extraordinary fashion. Two factors contributed to this. First, locomotives can run on wheels under their own power, and so do not have to be built in the locality in which they are to work. This means that while we might expect, by reason of the bulk of the raw materials required, that the industry would be primarily located in those areas where iron and steel were produced, it would not surprise us to find building centres in places remote from such regions where other local factors may have given rise to the industry. Secondly, it was the policy of the principal British railway companies (and in this respect they were almost unique in the world) to build most of their own engines and not to place extensive orders with engineering firms. This resulted in the setting up of a locomotive industry in a number of places

where, despite the distance from the raw materials, the railway companies concerned considered that the nodality of the site with regard to their particular system warranted the establishment of the works. Of the sixteen engineering companies which were building locomotives in the thirties, all

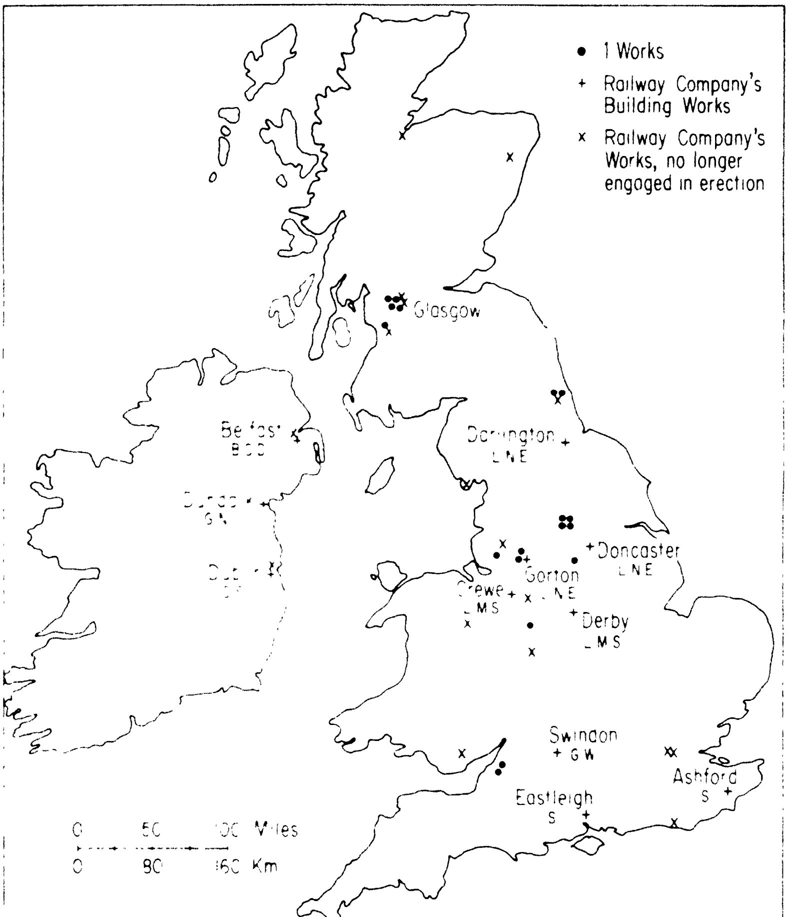



FIG. 180. Map showing locomotive-building centres about 1930. Initials refer to the railway companies which existed before nationalisation in 1948

but five were noticeably grouped about four nodes, each in the heart of one of the engineering provinces, based upon the coalfields, already mentioned (Fig. 180). The Glasgow–Kilmarnock area had four large works, three belonging to the North British Locomotive Co., which was the largest concern of its kind in Europe. Two works were situated on Tyneside and three, the largest that of Beyer, Peacock & Co., in the neighbourhood of Manchester. Another group of four had their headquarters in Leeds. The remaining works were situated at Darlington, Sheffield, Stafford, and two at

Bristol. With the exception of the Bristol works, both of which built locomotives mainly for industrial purposes (works, docks, etc.) and not for ordinary railways, all these locomotive-building establishments were essential components of that great engineering industry of Britain which owes its development to the proximity of iron and coal. Many of the works formerly belonging to the railway companies, on the other hand, were situated at some distance from coal and iron, and the only explanation of their location is that they occupy nodal points on the railway system to which, before nationalisation, they belonged. Such are Crewe, Swindon, Oswestry, Eastleigh, Brighton, Ashford, and Stratford.[1] The works of the railways which served the industrial north, however, were naturally situated near to their sources of raw materials, as Doncaster, Derby, Darlington, Gorton, Horwich, Kilmarnock, and St Rollox (Glasgow). The Irish centres, Dublin, Belfast, and Dundalk, are all ports on the east coast where the raw materials and fuel were most easily obtainable across the Irish Sea from England and Scotland.

After the amalgamation of the principal lines into four groups in 1923, the building of locomotives at many of the smaller and less well equipped works, e.g. Oswestry, Stoke, Barrow, Kilmarnock, Gateshead, and Cowlairs (Glasgow), was abandoned, their activities being confined to the execution of repairs; and subsequently the process of rationalisation still further reduced the number of works engaged in building.

*Export of steam locomotives* (tons)

| DESTINATION | 1913 | AVERAGE 1921–25 | AVERAGE 1926–30 | 1932 | 1937 | 1946 | 1948 | 1962 |
|---|---|---|---|---|---|---|---|---|
| Argentina | 11 571 | 2 686 | 7 814 | 91 | 114 | | 3 114 | |
| Brazil | 1 279 | 158 | 1 079 | | 2 151 | 748 | 827 | |
| Egypt | 224 | | 2 254 | 27 | 1 976 | | 835 | |
| India, Pakistan, and Ceylon | 14 810 | 16 622 | 14 037 | 672 | 1 571 | 14 142 | 515 | |
| Australia | 5 287 | 511 | 1 552 | 4 | 12 | 964 | | |
| South Africa | 3 878 | 2 382 | 1 868 | 62 | 798 | 9 711 | 9 039 | |
| British W. Africa | 635 | 1 533 | 1 047 | 501 | 611 | 254 | 2 021 | |
| British E. Africa | 1 094 | 825 | 1 338 | | | 474 | | |
| Other countries | 5 494 | 8 799 | 6 917 | 1 208 | 2 044 | 16 810 | 10 189 | |
| Total | 47 121 | 33 461 | 38 495 | 3 483 | 9 277 | 43 103 | 26 540 | 64 |
| Number of locomotives | ? | 662 | 681 | 169 | 147 | 437 | 280 | 2 |

Note: No *steam* locomotives have been exported since 1965.

1. The railway-created towns, Crewe and Swindon, will be more fully referred to in Chapter 27. See pp. 700–701.

All the preceding account of the locomotive-building industry has been written in the past tense because it refers to the building of steam locomotives, an industry which is virtually dead. The table of exports shows this also but at the same time is an indication of its former importance. No new steam locomotive has been built for British railways for some years; haulage as in most other parts of the world is by diesel or electric locomotives. One of the problems of British Railways (see p. 708) is that many of the building and repair shops shown on Fig. 180 are now redundant. The building and equipping of diesel and electric locomotives is an offshoot of electrical engineering (see p. 448), with major centres at Rugby, Loughborough and Preston, but the railway workshops at Crewe, Swindon and Derby continue to assemble and repair such locomotives for British Rail. Export destinations vary widely from year to year, but are mostly amongst the underdeveloped countries of the world.

*Export of locomotives, 1966* (tons)

| DESTINATION | DIESEL | ELECTRIC | RAILCARS |
|---|---|---|---|
| Mexico | | — | 1021 |
| Nigeria | 890 | | — |
| Cuba | 423 | | — |
| Mozambique | 312 | | — |
| Canada | | 292 | — |
| India | 48 | 215 | |
| Malaysia | 183 | | |
| Total | 2414 | 670 | 1238 |

## Motor vehicles

The motor industry is of comparatively recent growth. Undoubtedly its early location stemmed from that of the bicycle industry, which expanded greatly after about 1860 in Birmingham, Wolverhampton and Coventry so that by 1914 bicycle manufacture was the third largest employer in the West Midlands, after brassfounding and jewellery. The first Lanchester car was made in Birmingham in 1893, the first Daimler at Coventry in 1896. The Rover factory began in 1896, Standard in 1903 and Austin in 1905. Commercial vehicles began with Daimler at Coventry, followed by Standard in 1912 and Guy at Wolverhampton in 1914. The growth of these car-building plants engendered the development of the components industry—metal castings, stampings and forgings in the Black Country, springs in Redditch and West Bromwich, steel tubes in Birmingham, and so on, and also provided a great stimulus for the rubber industry (Dunlop began in

Birmingham in 1890), and for the machine tools industry that provided the wherewithal to fashion the parts.

By 1907 the motor industry claimed 53 000 employees; by 1931 the total had risen to 190 000, and by 1966 there were half a million.

*Production of vehicles, 1956, 1966 and 1969* (thousands)

| TYPE OF VEHICLE | 1956 | 1966 | 1969 |
|---|---|---|---|
| Aircraft | 1.6 | 0.4 | – |
| Passenger cars | 708 | 1604 | 1717 |
| Commercial vehicles | 297 | 439 | 466 |
| Tractors | 109 | 214 | 180 |
| Motor cycles | 124 | 105 | – |
| Pedal cycles | 2873 | 1423 | – |

Between the wars the motor-car industry witnessed a gradual concentration into big firms; the number of manufacturers fell from forty to twenty-five; and after the Second World War, Austin merged with Morris to form the British Motor Corporation, Leyland with Standard-Triumph, and Jaguar absorbed Daimler, Guy and Coventry Climax; and more recently Leyland merged with British Motor Corporation. Jaguar and Rover survive on the basis of high-class products—but both are in other sections of the industry as well, Jaguar with commercial vehicles and Rover with Land Rovers. Only a few of the relatively small firms have survived – like Morgan at Malvern, Jensen at West Bromwich and Reliant at Tamworth.

It cannot be too strongly emphasised that the motor industry is essentially an *assembly* industry; the average motor car has no less than 20 000 components, made from many diverse materials—ferrous and non-ferrous metals, plastics, glass, leather, upholstery, rubber, and so on. Consequently its ramifications extend far beyond the localities—such as Cowley, Dagenham and Longbridge—that catch the public eye. About 24 per cent of the national employment in vehicle manufacture is in the West Midlands (it was 40 per cent in 1931), in which region 11.6 per cent of all the manufacturing employment is provided directly by the motor industry. Such is the importance of component manufacture, however, that no less than 45 per cent of all the manufacturing employment in the region is in firms that have *something* to do with the vehicle industry.

The factors that have influenced the location of the vehicle-building industry are five: (*a*) the fact that it attached itself to localities where the cycle industry already flourished; (*b*) the very wide range of industrial products that enter into a motor vehicle; (*c*) the skilled character of much of the work involved—at least in earlier years and before the development

of mass-production on assembly lines—so that an attachment to already existing engineering localities was natural enough; (*d*) the ready transportability both of the component parts and of the assembled vehicles, so that 'raw material' supplies exercise little control over location; and (*e*) Government encouragement or direction towards 'Development Areas' where vehicle assembly can provide much-needed employment and a boost to the local economy.

Outside the West Midlands—where the three major centres, Coventry, Birmingham and Wolverhampton, each have all branches of the industry represented—the main localities are in metropolitan England, and more recently in Lancashire and in Scotland. In the London region the presence of a huge population, the existence of numerous other engineering trades and the great demand for vehicles have contributed towards the rise of the motor industry. The Associated Equipment Co., which builds London's buses, is located in the western suburbs, whilst the Ford works is situated on Thames-side at Dagenham. Luton (Vauxhall) may be regarded as a self-contained 'satellite' of London, as also may Oxford. Here, at Cowley, from small beginnings (actually a bicycle-repair shop) the enormous business of Morris (Viscount Nuffield) was built up.

Outlying older centres are Crewe (the home of Rolls-Royce) and Bristol, together with Manchester and Leyland in south Lancashire, where the existence of many other engineering industries and the presence of a large labour force encouraged the growth. Leyland is the greatest centre for commercial vehicles.

The new areas in the industry owe their existence to Government encouragement of manufacturers to set up in the Development Areas that are in need of economic resuscitation. On Merseyside, since 1960, a vast plant (covering over 140 hectares and employing 11 000 in 1968) has been set up by Ford at Halewood on the Lancashire side, whilst Vauxhall employs nearly 11 000 people at Hooton, near Ellesmere Port on the Wirral side. A third plant, begun in 1966 at Speke, near Liverpool, belongs to Standard-Triumph (now part of the Leyland BMC group). The total employment in the motor industry on Merseyside in 1968 was over 26 000.[1] In Scotland, the Rootes group have an assembly works at the new industrial town of Linwood, twelve miles southwest of Glasgow, and BMC are located at Bathgate, halfway between Glasgow and Edinburgh.

To an increasing extent the fabrication of motor-car bodies has become separated from the assembly plants. The pressing of sheet steel (much of it from Port Talbot) into body shapes takes place at Llanelli, Swindon, Wolverhampton and other places, and the bodies are transported on double-decked road vehicles or rail cars to the assembly plants. As for components, while it is true that thousands of individual firms contribute in one way or another, there is a remarkable concentration in the west Midlands, and

1. J. Salt, 'The motor industry on Merseyside', *Geography*, 53, 1968, 320–2.

some firms exercise a most powerful influence. Thus Lucas of Birmingham produce about 90 per cent of all the electrical equipment used by the motor industry (lamps, dynamos, wind-screen wiper motors, etc.), and about 85 per cent of all clutches come from a firm in Leamington Spa. Most of the chromium-plated fittings are produced in the Black Country, as are castings and engine components; wheels are made in Wellington (Salop), Bilston, Darlaston and Coventry; of the major tyre-producing firms Dunlop, Pirelli, Michelin and Goodyear are all located in the west Midlands. All the new assembly plants in other parts of the country have to rely for almost all their component supplies on the west Midlands.

The phenomenal rise of the motor industry as an exporter of major importance is shown in the following tables.

*Export of motor vehicles* (thousands)

| | 1913 | 1931 | 1935 | 1950 | 1960 | 1964 | 1969 |
|---|---|---|---|---|---|---|---|
| Motor-cars | 8 | 19 | 46 | 274 | 570 | 680 | 772 |
| Tractors | | | | 86 | 155 | 170 | 133 |
| Commercial vehicles | | | | 70 | 146 | 164 | 179 |

*Export of motor vehicles (cars)* (value in £ thousands)

| COUNTRIES | 1950 | 1962 | 1966 |
|---|---|---|---|
| Australia | 64 858 | 12 132 | 12 979 |
| Canada | 26 151 | 17 731 | 14 291 |
| Sweden | 11 451 | 7 738 | 6 634 |
| New Zealand | 10 192 | 11 262 | 13 040 |
| S. Africa | 8 883 | 12 140 | 17 237 |
| India | 6 477 | 779 | 22 |
| USA | 8 270 | 40 829 | 51 704 |
| Brazil | 5 158 | — | 37 |
| Netherlands | 5 225 | 5 512 | 8 288 |
| Others | 43 267 | 105 811 | 128 024[1] |
| Total | 189 932 | 213 934 | 235 019 |

[1] Includes Denmark £9.2m, France £9.2m.

## Aircraft

Closely allied to the motor industry is the aircraft industry, which in 1966 gave employment to 255 000 people in a large number of factories. It was at

first less concentrated, and more widely scattered, than the motor industry, partly, no doubt, for strategic reasons and partly due to its need for airfields. The 'big four' in the industry are Hawker Siddeley, British Aircraft Corporation, Rolls-Royce and Bristol Siddeley, who between them employ 160 000 people. The next largest is Short's of Belfast, and there are many smaller specialised firms. The activities of the 'big four' are more or less evenly divided between four major areas—the northwest (especially Manchester and the Preston area), the Midlands (especially Coventry and Derby), the southwest (Bristol and Cardiff) and the southeast (many centres from Hurn and Hamble to Weybridge and Kingston, Hatfield, Stevenage and Luton), with outlying centres in the Glasgow area and at Brough in East Yorkshire. Engine production is concentrated mainly in Derby, Bristol and Coventry. The industry is also concerned with the production of rockets and other missiles.

*Road vehicles and aircraft—exports* (£ million)

| | CARS | COMMERCIAL VEHICLES | MOTOR CYCLES | CYCLES | AIRCRAFT |
|---|---|---|---|---|---|
| 1913 | 2·4 | | | | 0·05 |
| 1931 | 3·4 | | | | 1·9 |
| 1935 | 6·3 | | | | 2·7 |
| 1950 | 190 | | | | 34 |
| 1955 | 120 | 37 | 7 | 21 | 40 |
| 1960 | 218 | 39 | 5 | 14 | 62 |
| 1962 | 214 | 43 | 4 | 11 | 41 |
| 1966 | 234 | 136 | 13 | 7 | 130 |

The totals include also chassis, parts, spares, etc., but not aircraft engines which in 1966 were valued at £71m.

## Electrical engineering

With the development of domestic electricity and more recently of radio and television, the smaller electrical trades have expanded rapidly and have spread over many parts of the country; for the produce comprises for the most part small but valuable consumer goods, manufactured from a great variety of raw materials, and the industry can thus be carried on almost anywhere, the site depending more on the availability of labour and markets than upon railway facilities or the location of raw material supplies. The more prosperous cities and conurbations have attracted a great variety of such industries—radio, batteries, lighting accessories—which together in 1948 employed 235 000 people and 260 000 (115 000 women), in 1962, but which would perhaps be more appropriately treated in the chapter on

Miscellaneous Manufactures since they depend to only an insignificant extent on iron and steel.

The heavy electrical trades, however (i.e. the construction of heavy electrical machinery and power-producing plant), which employ large quantities of iron and steel, often of special qualities, are more definitely localised. They employed in 1962 some 225 000 people (compared with only 149 000 in 1935), of which a third were in the Midland Region, a quarter in the Northwestern Region (mainly south Lancashire) and nearly a quarter in London and the Southeastern Region. In almost every case, the only important exception being Rugby, the industry is located in towns and cities where a flourishing machinery industry of one kind or another already existed; railway facilities have also played a part, for adequate means of transport are essential to an industry which imports much of its raw material (copper, mica, etc., from abroad and heavy steel castings, probably from Sheffield), and produces bulky and valuable goods. The metropolis of the industry is at Manchester, the home of the Metropolitan-Vickers Co., which produces power plant and electric locomotives of all kinds. At Rugby, the forerunners of the English Electric Co. set up their works in 1897, and a huge industry, increased by the advent of the British Thomson-Houston Co. in 1901, has resulted. Heavy machinery and turbo-electric plant are made here. These are the principal centres. Others of less importance are Coventry (radio apparatus and other plant), Preston (electric motors, locomotives, and formerly tramcars), Birmingham (electric motors and other plant), Hebburn-on-Tyne (switchgear), Loughborough (turbo-electric motors and railway equipment), and Stafford (generators and industrial equipment).

Division 72 of the *Export List* is entitled 'Electrical machinery, apparatus and appliances', and includes generating sets, generators, motors, transformers, switch-gear, batteries, bulbs, lamps, radio and TV sets and parts, telegraph and telephone apparatus, cooking and heating and domestic appliances, electric cables and wires, accumulators and a wide variety of minor items. It is obviously meaningless to express exports by weight which was done previously and comparison with the past is difficult. The trade is worldwide: 120 countries are separately listed in the *Annual Statement of the Trade of the United Kingdom*. The value of exports rose from £170m in 1954 to £346m in 1966. In 1966 the chief customers in order were South Africa (£27m), Australia, USA, Netherlands, New Zealand, Canada and West Germany (£14m). Nothing could illustrate more clearly how Britain's prosperity, depending upon exports, depends upon maintaining worldwide trade connections. Sweden, France, Nigeria, Kenya, India, Iran and China are countries selected at random which were all customers to the extent of over £3m.

*Cables.* The manufacture of cables and wiring for the transmission of electrical energy—an industry which represents probably a half of the total capital invested in electrical concerns in Britain, and which employed some

53 000 people in 1963, mainly in Lancashire and the London area—is deserving of special mention. As an industry it represents a link between heavy electrical machinery and the non-ferrous metal trades (see Chapter 18). A moment's reflection upon the multiplicity of the uses of electric cables—for house wiring, post office and other telephones, railway signalling, power transmission, and submarine telegraphs—is sufficient to establish its importance in modern life.

Like the motor industry the manufacture of cables employs a great variety of raw materials: copper, aluminium,[1] and steel wires, insulating materials in the form of rubber, oiled paper, and cambric, lead and latterly plastics and aluminium for sheathing, jute to form part of the protective covering, and timber for the rollers upon which the finished products are mounted for transport. Many of these items must be imported and a large part of the produce is destined for export, so that we shall expect to find the industry located near the large ports, especially in the vicinity of the non-ferrous metal industry (cf. Chapter 18). The banks of the Thames below London as at Erith, Barking, and Northfleet—support nearly half the industry, whilst a considerable proportion of the remainder is localised in the important non-ferrous metal district of south Lancashire, at Manchester, Prescot, and Liverpool; Glasgow is the centre of the trade in Scotland, and Newport in South Wales. A recent addition to the list of localities is Wrexham, in the Development Area of northeast Wales.

## Engineering provinces

We may now comment briefly upon the various engineering provinces mentioned above, noticing the geographical factors which have helped to influence their development and the present-day trends of their industries. (See table on p. 457).

### Manchester and South Lancashire

Manchester is the hub of one of the world's greatest engineering districts. In 1931 some 217 000 people in Lancashire and the adjoining part of Cheshire were employed in the various branches of the engineering industry, about 22 000 being engaged in the textile-machinery industry alone. Yet south Lancashire is not, and never has been, a great iron and steel-producing area. As we have seen (p. 382), the coalfield was almost devoid of Coal Measure ironstones so that no great smelting industry arose; and at the present time there is only one smelting works in the whole of the area—at Irlam, west of

1. The increasing replacement of copper by aluminium as the conductor in cables for electrical distribution is shown by the following figures: use of copper 52 800 metric tons (52 000 long tons) in 1962, 22 300 metric tons (22 000 long tons) in 1968; use of aluminium, 4674 metric tons (4600 long tons) in 1962, 20 300 metric tons (20 000 long tons) in 1968.

Manchester. The momentum acquired by the early textile machinery industry, however, assisted by the availability of coal and the ease of access to supplies of iron and steel from Staffordshire and Yorkshire (by railway) and from Cumberland and Scotland (by sea), has been sufficient to attract a large number of heavy-engineering industries to the area, and the 'deposit' of technical skill, which has been gradually accumulating since the eighteenth century, has found outlets in the designing and building of steam and other engines and all kinds of heavy machinery.

Three of the most important branches have already been noticed – textile machinery, electrical machinery, and locomotives. In addition, many firms are engaged in building stationary steam engines and other power-producing plant (gas and oil engines, boilers, etc.). Since James Nasmyth (of Salford) invented the steam hammer, vast strides have been made in the efficiency of the machines which fashion the parts of the engines and machinery. The heavy machine-tool trade is the greatest in the country, and probably nine-tenths of the machines used in the manufacture of armaments, shafting, and heavy forgings in Sheffield are made in south Lancashire. The list of engineering products is almost unending. Mining, colliery, and saw-mill plant, and machinery for numerous food-preparing trades, wire ropes, cables, and chains, hydraulic machinery, and constructional steelwork are among the most important. After Manchester and its suburbs the chief engineering towns are Blackburn, Bolton, Preston, and Oldham (cf. Fig. 196).

## The Yorkshire, Nottingham, and Derby coalfield

(*a*) *The West Yorkshire Conurbation.* The engineering industries of west Yorkshire as a whole employed, in 1931, over 111 000 people. The geographical bases of the industry are similar to those which are found in the case of south Lancashire, namely the early start in the manufacture of textile machinery and the ease of access to coal and iron. In contrast with Lancashire the importance of local iron manufacture – mainly south of Bradford—has been considerable, but the industry, famous for 'Best Yorkshire' wrought iron, is now extinct. Within the area there is a tendency towards the segregation of the textile-machinery industry in the west – at Bradford, Keighley, Bingley, and Halifax – while locomotive manufacture and the heavy iron and steel trades are to be found mainly on the lower ground farther east, at Leeds, Huddersfield, and Wakefield. Apart from the textile machinery and locomotives already dealt with, the following engineering products may be cited: railway rolling stock and the materials therefor (wheels and axles), formerly tramway rails (probably 50 per cent of all the tram rails in Britain were rolled at Leeds),[1] machine tools, drilling and boring machinery, hydraulic apparatus and certain types of con-

1. Aberconway, *op. cit.*, 94.

structional steelwork (e.g. gasholders). All these trades employ iron and steel from Middlesbrough, Scunthorpe, and Sheffield.

(*b*) *South Yorkshire.* The unique industries of Sheffield (cf. Chapter 16, p. 413) are divisible into two groups: (1) cutlery and small articles,[1] e.g. hand tools, clock springs, and pen nibs; (2) the heavy steel trades. The latter include huge castings and forgings for ships and heavy machinery, armour plating, guns, and certain types of railway and electrical apparatus where special hardness, strength or magnetic properties are required. Some of the names in the Sheffield steel industry are world famous: Firth's (stainless steel), Vickers (the Manchester electrical engineers, and Barrow shipbuilders), Cammell Laird (the Birkenhead shipbuilders), John Brown (the Clyde shipbuilders) and Hadfield's (the pioneers of manganese steel) are amongst the best known.

Rotherham takes part in two types of Yorkshire industry, the special steel manufacture of Sheffield, and the wrought and cast iron trade which developed on the coalfield in the early days of iron smelting. Like Sheffield, it makes, at the Park Gate and other works, special steels and their products heavy castings and forgings for marine engines and other machinery. Side by side with this have developed the railway rolling stock and constructional steelwork trades. Very different, and much older, however, are the wrought-iron industry and the manufacturing of stoves and grates.[2]

(*c*) *Derbyshire and Nottinghamshire.* The industries of this group, while owing their origin to the presence of coal and iron, are more allied by their miscellaneous character to the scattered engineering trades of southeastern Britain. It is probably due to the towns themselves not forming a coherent whole, and to the absence of any vast industrial occupation, such as textiles or shipbuilding, which could generate a machinery industry. Typical of the area (apart from the locomotives and hosiery machinery already referred to) are the chains, castings and refrigerating machinery of Derby, the cycles of Nottingham, the tubes of Chesterfield, and the cast iron pipes produced at the Stanton and Staveley ironworks.

## The Northeast coast

The two characteristic engineering industries of this region are the building of marine and locomotive engines, located principally on Tyneside, and the production of ship plates, rails, and constructional steelwork, centred upon Tees-side. Marine engineering is a natural accompaniment of shipbuilding, and locomotive building is a kindred industry which here, as on

1. Employment in cutlery industry, 10 000 in 1960.
2. It is interesting to recall that the plates for the 'Great Eastern' were rolled at Rotherham (cf. p. 432).

the Clyde, assumed large proportions (cf. pp. 434 and 441). The constructional steelwork (girders for bridges and buildings) produced by Dorman Long and other famous bridge builders of Tees-side is a peculiarity the origin of which is less obvious. There are two factors to be borne in mind:

(*a*) The iron industry of Tees-side began much later than those of the coalfields, in an area where there was no previous industrial development and no existing machinery industries.
(*b*) The coastal site favoured the growth of an industry which specialised in bulky, unwieldy products for which a large market existed abroad. Thus the heavy machinery industries never developed, and the principal products, apart from the export of iron and steel to other areas, have been shipbuilding steelworks, rails, and girders. Triumphs of Tees-side include the steelwork of Sydney Harbour Bridge, of the Little Belt Bridge in Denmark and of the Lower Zambezi bridge. Darlington is also famous for its bridge building materials. Stockton is the headquarters of a firm that produces mining equipment and iron- and steelworks plant.

## The Scottish lowlands

The western portion of the Scottish lowlands, centring on Glasgow, but extending northeast to Falkirk and southwest to Kilmarnock, is a great engineering province for three reasons:

(*a*) There are excellent facilities for the production of iron and steel from local and imported materials.
(*b*) For a period in the 'thirties and 'forties of last century central Scotland was the most important iron-producing region in Britain, and consequently was a centre of attraction for many engineering industries.
(*c*) The shipbuilding industry naturally gave rise to a marine engineering industry, and the skill acquired in this branch could easily be applied to other branches of engineering.

The region thus partakes of the characteristics of both Manchester and Tyneside. In 1930 about 90 000 people were employed in the engineering trades.[1] The great marine-engineering industry of the Clyde, formerly employing 20 000 people, has already been dealt with, and we have seen that Glasgow was the most important locomotive-building centre in the British Isles. The textile machinery industry is present, though it bears no comparison with that of south Lancashire. One firm at Clydebank, however, employs 10 000 people in the manufacture of sewing machines. As a natural accompaniment to locomotive building, we have boiler making (e.g. Babcock and Wilcox), and the production of stationary steam engines

1. *Industrial Survey of South-west Scotland*, p. 63.

and pumps. These trades, together with marine engineering, have given rise to an extensive manufacture of machine tools, in which branch the Glasgow district seriously rivals the Manchester area. Glasgow leads the world in the production of machine-tools for the building of marine engines; and it is the chief centre in Britain for the production of mining equipment, such as coal-cutting machinery. Constructional engineering is another natural outlet for the steel of a seaboard region; and among the many firms engaged in this branch the most famous is that of Arrol & Co., the builders of the Forth, Tay, and Tower bridges. Other characteristic products of this province are steel tubes, hydraulic engineering machinery, sugar-making machinery (a result of Glasgow's former important trade with the West Indies), and various types of cast iron articles such as stoves, grates and baths, for which the Carron company, for example, is specially noted. The most recent introduction is heavy electrical engineering—a natural result, perhaps, of the development of hydro-electric power schemes in the Highlands.

### Northern Ireland

In recent years Northern Ireland has become increasingly important as a centre of engineering, apart from the shipbuilding already noted, aircraft building and textile machinery.

The products of the many engineering firms are numerous and varied, including fans for mine ventilation, machinery for tea and coffee estates, turbines and turbine blades, tabulating machines, electronic computers, telephone exchange equipment, oil well drilling and ancillary equipment, radios, gramophones, tape-recorders, cameras and cutlery, and car tyres.

### The Black Country and Birmingham

The Black Country is the oldest of the great engineering provinces, and the origin of its iron and steel industry has already been discussed (Chapter 16, p. 409). Even in the sixteenth century the manufacture of nails, knives, and locks was going on in the area,[1] and the momentum given by this early start, by the fortunate occurrence in juxtaposition of the raw materials of the iron industry, and by the steam-engine trade of Boulton and Watt in the last twenty years of the eighteenth century, enabled a vast engineering industry to be built up. Birmingham, not on the coalfield, quickly began to specialise in small valuable articles, while the heavier industries concentrated in the Black Country. The interior position of the region was originally a disadvantage, but the nodality which resulted from the construction of canals and railways meant that all districts could be equally well served, though shipbuilding and marine engineering could hardly be expected to develop.[2]

1. Leland's *Itinerary*, vol. iv, fol. 186.
2. It is interesting to recall, however, that one of the very earliest iron steamships—the *Aaron Manby* of 1822—was actually built at Tipton and sent in sections by canal to London for assembly and launching!

As a result the dominant note of the engineering industry became *variety*. The decline of iron smelting has been accompanied by an even greater specialisation in all kinds of engineering industries based on local steel produced from non-local ores and scrap. The localisation of many of these industries is not geographically explicable, being often almost accidental and due to the chance decision of a manufacturer of certain goods to set up his factory in a particular spot. Interesting local specialities, the origins of which are buried in history, are to be found at Willenhall (locks), Darlaston (nuts and bolts), Wednesbury (tubes), West Bromwich (coiled springs), Cradley Heath (chains), and Walsall (saddler's ironmongery).[1]

Only the outstanding products can here be indicated. The list is so extensive that any enumeration must omit many important ones. Amongst the principal *groups* of products, however, the smaller usually included under the term 'hardware', the following seem to be characteristic: chains (especially for ships' anchors); locks and keys; nuts, bolts, and screws; steel tubes; iron castings of every description; stoves, grates, and fireirons (and their modern developments, gas and electric fires); constructional steelwork; railway rolling stock; and many kinds of steam and other engines and machinery. The iron hollow-ware (now frequently called in the trade 'holloware') industry has been very largely replaced by the manufacture of similar articles in aluminium (see p. 477)[2]

The trades of Birmingham are of such bewildering variety that it is impossible to give an adequate selection. So many of them, moreover, involve the use of other metals than iron and steel that the discussion may best be deferred (p. 485).

## The smaller Midland coalfields, and adjacent areas

(*a*) *North Staffordshire.* Much of the iron smelted in this region is sent away, either as pig iron or as semifinished steel, to other areas, notably south Lancashire and the Black Country. There is a small engineering industry concerned chiefly with foundry products and with machinery for the local pottery industries in Stoke-on-Trent. But Stafford, largely by reason of its excellent rail facilities (for it is off the coalfield), has become an engineering centre of major importance, formerly with locomotive-building, now with heavy electrical engineering, and reinforced concrete engineering. Uttoxeter, long famed as an agricultural market, produces farm machinery.

(*b*) *Warwickshire and Leicestershire.* This group, like Derby and Nottinghamshire, has a number of miscellaneous iron and steel industries. Stoves and

1. See British Association for the Advancement of Science, Handbook, *Birmingham and its Regional Setting*, 1950, pp. 161–248.
2. Employment in 'Hardware and Holloware' industry, 1948 (*Census of Production*): Great Britain, 175 297, of which 61 723 in Midland Region (i.e. mainly Birmingham and the Black Country).

grates are again prominent, as at Leamington and Warwick (which also has motor-car assembly). Coventry has a vast trade in castings, forgings, and tools for its great motor, cycle, and aeroplane industries. Leicester makes, amongst other things, heating and ventilating plant, machinery for its own hosiery and boot and shoe trades, and stone-crushing apparatus (possibly a result of the proximity of the Charnwood quarries); and Rugby and Loughborough, as mentioned above, are important centres for the manufacture of all kinds of electrical apparatus and machinery.

## Southeastern Great Britain

The scattered engineering industries of the region lying southeast of a line from the Humber to the Bristol Channel owe their origin in many cases to the agricultural implement manufacture, which arose at certain nodal points in this the essentially arable part of Britain.[1] In other cases the industries have developed largely because (*a*) good railway facilities permitted easy access to sources of raw material; (*b*) the local population provided at one and the same time a ready market for the articles produced and a source of labour supply. Of the towns where agricultural machinery formed the basis of the engineering industry, the most important are Lincoln, Gainsborough, Grantham, Thetford, Leiston, Ipswich, Colchester, and Rochester.

Reference has been made earlier to the almost complete mechanisation of British agriculture and the huge expansion of the demand for tractors and agricultural machinery of the most varied and increasingly complex types. The outlook has broadened from the old emphasis on ploughs and reapers. Lincoln is probably the chief centre outside North America for the manufacture of excavating machinery: Ruston-Bucyrus draglines and face-shovels are used the world over. In addition, every type of road locomotive (road rollers, traction engines, etc.) is made, together with a variety of agricultural machines and boilers and engine parts. Gainsborough makes dredges; Ipswich makes cranes, excavators, railway material, and electric road vehicles; Colchester deals in boilers and gas engines; Grantham has a large output of petrol-driven farm machinery and road rollers of all kinds.

Of the second class of towns the locomotive-building centres have already been mentioned. A few others may be cited as examples, but it must be remembered that, as pointed out previously, almost every town has an engineering works of some kind. Northampton makes stoves and grates and boot-making machinery; Bedford such things as pumps, oil engines, and electrical gear; Luton makes motor cars, ball-bearings, refrigerating plant; Guildford makes specialised motor vehicles such as fire engines, refuse

1. This industry began, no doubt, by the keener farmers inventing their own mechanical devices, and became commercialised by the setting up of workshops in the market towns where the farmers congregated. Cf. *Victoria County History*, *Lincolnshire*, vol. ii, pp. 394–6.

collectors and lawn mowers; Yeovil makes oil engines; and Oxford has already been mentioned in connection with the motor-car industry.

Despite the absence of coalfields, this southeastern region, taken as a whole, is the greatest engineering province of all. True, it is unlike the other regions in being far more widespread and in containing far more numerous and scattered individual centres, but within it the great city of London, as the table opposite shows, is the largest employer of engineering labour in the country. The multifarious engineering trades of London are referred to elsewhere (pp. 485, 673–5), but we might note here the importance of the electrical and motor trades and of the miscellaneous group. To provide raw material for some of these industries London has over 500 foundries (iron and non-ferrous), 10 per cent of all those in the country.

### South Wales

Finally, attention may be called to South Wales. In this area neither shipbuilding nor any great engineering industry has developed[1] despite the early importance of the iron industry. The reason is to be found (*a*), in the location of the early smelting works in narrow valleys miles from the coast, and (*b*) in the great development of the tinplate industry (see above) which absorbed much of the steel output. Only the manufacture of rails and sections, an industry lying on the borderline between the *production* of iron and steel and engineering proper, was of any importance. This absence of any great manufacturing industry was largely responsible for the disastrous interwar unemployment in eastern South Wales, which resulted from the decline of the inland centres and the working out of the best coals in that same northeastern region.[2]

## The electronics industry

This industry is basically a highly specialised branch of the electrical industry. Half the output is concerned with radio and television reception and transmission but the field includes automation in industry with computers and business machinery, navigational aids and radar, guided weapons and fire control equipment, and sound recording and reproducing apparatus. The basic component in the industry, the thermionic valve, was invented by Ambrose Fleming in 1904, but is now being supplanted by the transistor. The word electronics does not even appear in the 1933 supplement to the *Oxford English Dictionary*; in 1960 the total labour force in the

1. Newport was quite an important shipbuilding centre in the days of wooden ships, but the industry declined when iron came into favour. It was revived in 1953 with the opening of a new shipyard in which prefabricated sections are assembled in dry dock, and the finished hulls floated out into the River Usk and so to Newport Docks for completion.
2. See *Industrial Survey of South Wales*, Chapter 3.

British industry was estimated at 237 000 and, early in 1959, 400 firms were participating. These include subsidiaries or branches of the great electrical firms, set manufacturers concentrating on standard equipment and the makers of specialised components. Most operate in large units of 500 to 5000 workers in modern well-equipped factories. Two-thirds of the labour force are in the Greater London area especially in the outer ring of suburbs —Hayes, Enfield, Ilford, Croydon, and Sidcup—or slightly further out at Chelmsford, Southend, Slough, and Welwyn. A previously little used reservoir of unskilled female labour has been tapped and other factors favouring the choice of Greater London have been industrial linkage between the specialised sections of the industry and the fragile nature of the products making them very suitable for direct delivery in small lots to

*Employment in engineering industries in 1966* (thousands)

| MINISTRY OF LABOUR REGIONS | ELECTRICAL ENGINEERING | MOTOR VEHICLES | SHIP-BUILDING AND MARINE ENGINEERING | AIRCRAFT | MACHINE TOOLS | TOOLS AND CUTLERY | OTHER ENGINEERING INDUSTRIES | TOTAL |
|---|---|---|---|---|---|---|---|---|
| 1 Scotland | 26 | 30 | 48 | 14 | 7 | 1 | 146 | 272 |
| 2 Northern Region | 52 | 12 | 42 | 2 | 4 | 1 | 81 | 194 |
| 3 NW Region | 142 | 85 | 28 | 35 | 13 | 2 | 202 | 506 |
| 4 Yorks and Humber | 30 | 35 | 7 | 10 | 28 | 17 | 155 | 283 |
| 5 W Midlands | 121 | 179 | 1 | 24 | 45 | 6 | 320 | 697 |
| 6 E. Midlands | 37 | 25 | 1 | 27 | 8 | 1 | 114 | 214 |
| 7 Wales | 27 | 153 | 4 | 7 | 2 | | 51 | 245 |
| 8 London and SE. Region | 358 | 179 | 32 | 67 | 39 | 11 | 495 | 1180 |
| 9 London | 199 | 64 | 8 | 13 | 16 | 6 | 264 | 571 |
| Total persons employed in Great Britain | 865 | 576 | 178 | 230 | 153 | 40 | 1826 | 3872 |
| Total areas 1–8[1] | 794 | 560 | 162 | 177 | 147 | 39 | 1563 | 3591 |
| Total employed in GB 1961 | 726 | 539 | 173 | 267 | 139 | 32 | 1477 | 3353 |
| Total employed in GB 1950 | 533 | 518 | 278 | 140 | 77 | 52 | 1786 | 3390 |
| Total employed in GB 1931 | 242 | 348 | 151 | * | * | 43 | * | 1483 |
| Total employed in GB 1921 | 175 | 275 | 410 | * | * | 56 | * | 1910 |

* Comparable figures not available.
[1] Areas omitted from the table are Southwest, South, and East.

retailers in the very large local market. Somewhat similar considerations have favoured development in the West Midlands. Other centres are found in Lancashire, on Tyneside and in central Scotland (especially Fifeshire) where Government direction of industry into Development Areas, and a search for a labour supply for a rapidly expanding industry have been major factors.

# 18
# The non-ferrous metal industries

The term non-ferrous applies to all metals other than iron. Of a somewhat lengthy list, however, we are only concerned with a few which are in every-day use for domestic and industrial purposes. These fall roughly into three groups:

1. Some of the *baser metals*, such as tin, lead, copper, and zinc, have from very early times been wrought extensively in various parts of Britain, and the home-produced ores, though now almost negligible and supplemented by imports of ores, concentrates, and metal, have given rise to smelting and manufacturing industries of major importance.
2. Other of the *baser metals*, such as nickel, chromium, and aluminium, have found an increasing number of industrial uses during the present century. They are mostly imported.
3. Ores of the *precious metals*, gold and silver, have never been worked in any great quantity in Britain,[1] but the demand of a highly civilised and, on the whole, wealthy community for jewellery, plate and ornaments is responsible for the existence of a large industry concerned with the refining and fabrication of the imported metals.

Much metal wealth, especially of tin and lead, probably still remains locked up in British rocks (cf. p. 357), but the once important veins of Cornwall, Derbyshire and elsewhere cannot under present economic conditions hope to compete with the large-scale output from much richer areas abroad; the result being that the mining of non-ferrous ores in Britain is now virtually an extinct industry, and the manufactures to which the home deposits originally gave rise must now be carried on almost entirely with imported foreign ores, concentrates, or crude metal.

There are many areas of the country where non-ferrous ores have been worked, and many thousands of extinct mines (some 4000 disused lead mines in Derbyshire alone). But the life of a metalliferous mine is generally, with some very notable exceptions, comparatively short. Hunt calculated[2] for a thirty-year period in the second half of the last century that of 220 Cornish mines only thirty-five had a life of over twenty years, whilst no less

1. Considerable quantities of silver have from time to time, in the past, been obtained from argentiferous ores of lead, in the Mendips, Derbyshire and elsewhere. See also pp. 359, 461.
2. Quoted in *Mem. Geol. Surv., Min. Res.*, vol. xxvii.

than 114 were productive for less than five years. As every mine must have a dump heap of the useless rock dug out during the mining operations, and an erection of some kind at the head of the shaft, it is obvious that the effect on the landscape of those areas which have been thoroughly worked in the past must be considerable; and many a Cornish and Welsh panorama is marred by the ugly excrescences which betoken an activity which is, alas, rapidly fading into insignificance.

The industries based upon the non-ferrous metals and their extraction fall naturally into two distinct divisions: (*a*) the smelting and refining of the ores, and (*b*) the working up of the metal into manufactured articles. The geographic and economic influences bearing upon the location of the two branches are rather different. In the case of the smelting it must be borne in mind that most non-ferrous ores are very much poorer in their metallic content than ores of iron. A percentage as low as one per cent may prove profitable if the ore is in sufficient quantity and easily accessible. The ore from the world-famous Anglesey mines, once the most productive in the world, only averaged four per cent of metallic copper. It is thus not an economic proposition to smelt the ores far from their place of origin, unless cheap water transport be available, or unless the ore can be conveniently concentrated so that its metallic content is increased, say, to over 50 per cent. With inland ores smelting will most probably take place at the mines; should the ore lie near the coast it may be exported raw or in concentrated form to ports more favourably situated with regard to coal. The Derbyshire lead was always smelted on the spot; the Cornish copper ores were sent across the Bristol Channel to the ports of southwest Wales.

The location of the manufacturing industries is dependent on at least three factors, the existence of a supply of raw material in the form of refined metal, a suitable labour supply, and the presence of a market for the finished goods. Should the market be a scattered one, it can scarcely be expected to influence the siting of the works, for one locality would be as good as another. In these circumstances the factories may either be set up in the vicinity of the smelting and refining plants, or distributed in a haphazard fashion over the country. If, on the other hand, the market is localised in a particular region or regions, the tendency will be for the manufacture to take place as near as possible to those areas. A second consideration concerns the wastage of the raw materials during the process of manufacture. If there is little or no waste the amount of material to be transported is much the same whether the raw materials or the finished goods are sent, and so it matters little where the industry is located on a line drawn from the source of the raw materials to the market. If, however, there is a great wastage of material the market will exert much less attractive power, and the manufacture will tend to be located near the source of supply of the raw material.

With these general principles in mind, we may proceed to examine in some detail the past and present distribution of the non-ferrous metal in-

dustries in Britain, paying special attention to the changes in location which have occurred, and to the geographical influences (in this case mainly a combination of geological and economic factors) which have been foremost in producing them.

## The development of the non-ferrous metal industries

### From the earliest times to the reign of Elizabeth I[1]

The early history of the working of non-ferrous metals, like that of iron, is lost in obscurity. It is probable, however, that the western end of the Cornish peninsula, with its indented rocky coast, and the adjacent Scilly Isles were the Cassiterides to which the Phoenicians came from at least the fifth century B.C. to trade in tin with the natives.[2] By the time of the Roman occupation there is abundant evidence, both literary and *in situ*, of the great use which the Romans (with the help doubtless of their slaves) made of Britain's metal wealth. The historian, Diodorus Siculus, writing of the Cornish tin trade just after Caesar's time, records the collection of the smelted tin on Ictis Isle (probably St Michael's Mount) and its purchase by the merchants for shipment to the coast of Gaul and thence to Marseilles and the Mediterranean, and a block of tin such as he describes has actually been dredged up from Falmouth harbour. But it was lead that the Romans chiefly prized, and the results of their mining and smelting operations are to be found in such widely scattered localities as the Mendips, Derbyshire, Flintshire, western Shropshire, Alston Moor and Leadhills. A very fair technique had been attained, for numerous pigs of lead have been unearthed bearing the inscription 'ex arg' (*ex argento*, freed from silver), and Pliny refers to the large supplies of lead pipes and sheeting which Britain produced. In addition, the Romans are known to have worked the copper ores of Anglesey and Shropshire, while it is not improbable that they obtained a certain amount of gold from mines in North Wales and Carmarthenshire.

All these early efforts were either stream-works or else mere surface scratchings. The natural environment in which the ores occurred was par-

1. Much valuable literature on this subject will be found summarised in the *Victoria County Histories* (vol. ii in each case) of *Cumberland, Derbyshire, Durham, Somerset* and *Yorkshire*.
2. Cassiterides, from Greek *cassiteros* = tin. See W. C. Borlase, *A Historical Sketch of the Tin Trade in Cornwall*, 1874. Herodotus (fifth century B.C.) and Strabo (first century B.C.) each refer to the Cassiterides and their tin, and Polybius (second century B.C.) and Diodorus Siculus (first century A.D.) both mention tin in Cornwall, but no definite pronouncement seems to be made identifying the one with the other. A Phoenician bronze ornament has been found at St Just.

ticularly favourable to their discovery and utilisation. The veins were to be found in upland areas formed by palaeozoic rocks, and the thin soils and scanty vegetation of much of these districts permitted the surface exposure of the minerals; the heavy rainfall of most of the upland regions entailed a great deal of erosion by rushing torrents which would further expose and erode the veins and would sort and re-deposit the ore in their beds; while the peat cover of much of the moorland and the forests of the slopes would provide ample fuel for smelting purposes. The Cornish tin ore was probably all obtained from detrital deposits in which, owing to its high specific gravity (6.8), it accumulated whenever the velocity of the streams was insufficient to carry it further; and the ores of the other regions were obtained either from streams or by shallow diggings at the outcrop of the veins.

There are few records of mining or smelting during the Saxon period, and the only noteworthy reference in the Domesday Survey concerns lead mines at Wirksworth and other places in Derbyshire.[1] The first documentary evidence begins in the twelfth century, and the long series of Pipe Rolls contain frequent references to the mining industry, in which tin and lead are the chief items.

*Tin.*[2] In the twelfth and thirteenth centuries, the Cornish tin trade was mostly in the hands of Jews who may or may not have been the descendants of Phoenicians who settled in the country. Even to this day certain ruined smelting hearths and slag dumps are known as 'Jews-houses'. The banishment of all Jews from England in 1290 left Cornwall without its merchant smelters, but a revival of industry took place in the early fourteenth century with the passing of the first Stannary Laws (Latin *stannum* tin). So great a part did tin mining and tin smelting play in the lives of the people of Devon and Cornwall that from this time onwards for over four centuries the 'stannaries' had their own parliaments,[3] and a series of laws governing the mining, coinage and disposal of tin. 'Coinage' was the marking of the tin bars for taxation purposes. It took place generally once a year at certain 'coinage towns', whither the bars were brought from the neighbouring smelting houses. In Cornwall, Lostwithiel, Liskeard, Bodmin, Truro and Helston were appointed as coinage towns, and in Devon, Tavistock, Ashburton, Plympton and Chagford. The chief uses of tin were for the manufacture of pewter, as an alloy in bell-founding and as a soldering material. The pewter trade assumed large proportions in the fifteenth and sixteenth centuries, and a considerable export took place, largely controlled by Venetian merchants.

1. It is difficult to believe that tin mining had died out—but possibly, being considered as royal property, the mines were not recorded in a survey, the main purpose of which was the ascertainment of the value of estates for taxation purposes. (G. R. Lewis, *The Stannaries*, p. 34.)
2. Lewis, *op. cit.*, Chapter ii.
3. The parliament of the Devon 'stannary' met on Crockerntor and later at Tavistock; that of Cornwall met at Lostwithiel and afterwards at Truro.

*Lead.*[1] The twelfth and thirteenth centuries saw great activity all over the country in the erection of great buildings – especially churches and monasteries – and as a result the demand for lead for roofing and drainage purposes was greatly stimulated. Derbyshire was the chief centre, but the Pennine region of Durham and the Mendip Hills also had many mines and smelting hearths. Smelting of the galena was performed in 'boles' (simple hearths surrounded by a few bricks) using brushwood as a fuel. These boles were nearly always placed on the brow of a west-facing hill, in order to catch the breeze. Many such ancient furnace sites are known in Derbyshire and Durham, and the name 'Bole Hill' is of frequent occurrence in the former county. The fourteenth century probably witnessed the introduction of charcoal as a fuel, and also the development of waterwheels for working bellows which could create the necessary blast – with a consequent descent of the smelting industry into the valleys. At this time lead ranked with wool and leather as one of the chief exports of Britain.

## From the reign of Elizabeth I to the present day

The history of the non-ferrous metal industries from about 1550 to the present day may be briefly summed up as follows. A great fillip was given to mining and smelting in the Elizabethan period by the introduction of workmen from the continent who could and did teach the English how best to search for and make use of the metal wealth which the country possessed. The small existing industries were considerably expanded, and a number of new manufactures, such as those dealing with copper and brass, came into being. After a period of comparative quiescence during the troublous times of the middle seventeenth century, a great revival took place. The end of that century and the beginning of the next marked the foundation, in various parts of the country, of many branches of the industry which have survived, though perhaps in a modified form, until the present day. The increasing uses to which the metals were being adapted, together with the new lease of life given to the mining industry by the installation of the steam engine as a means of pumping out water from the ever-deepening mines, brought about a continued expansion of the industry during the eighteenth century. Stimulated by the development of manufacturing which accompanied the Industrial Revolution, and by the increasing employment of non-ferrous metals as well as iron in the fabrication of machinery, the output of British mines reached a maximum during the period 1840–80. About the same time, too, foreign ores, especially of tin and copper, began to be imported, and the smelting trade, notably in the Swansea area, enjoyed a period of great activity. Gradually, however, it became increasingly uneconomic to transport bulky ores for thousands of miles from overseas, and

1. See especially *Victoria County History, Derbyshire*, ii, 323–49; also J. W. Gough, *The Mines of Mendip*, Oxford U.P., 1930, 2nd ed, 1968; and A. Raistrick and B. Jennings, *History of Lead Mining in the Pennines*, Longmans, 1965.

as this trend has coincided with the decline, almost to nothing, of the home ore production, smelting has almost died out, and the structure of the non-ferrous metal industry has been radically changed. Most branches of the industry are carrying on as a result of momentum acquired during the period of prosperity, and are now based upon imported semifinished material in the shape of ingots and bars of refined or partly refined metal.

A more detailed examination of the development and distribution changes during this period will help to explain how the British non-ferrous metal industry and its dependants have been built up, and the part which they play in the economic organisation of the country at the present time.

In the middle of the sixteenth century, although tin and lead were still being worked, England lagged a good deal behind the Continent in industrial development, and early in the reign of Elizabeth it began to be realised that in order to improve conditions at home, to increase foreign trade, and to maintain the defences, metal industries were very necessary, especially those dealing with copper and brass, since those substances were used for the production of ordnance as well as for domestic utensils.[1] Accordingly, invitations were extended to certain German metal workers to take up their abode in this country and pursue their trade with British ores. In 1564 a small group of skilled men from Augsburg, led by one Daniel Höchstetter, landed in England, and in the following year, after rich copper deposits had been located at Keswick, several hundred workmen from the Tyrol were 'imported' and smelting works were set up. Many groups of German miners and metal workers subsequently came to Britain and settled in the mining districts, notably in Cornwall, the Mendips and in Northumberland, or started new metal industries in various parts of the country.[2] Two companies were subsequently formed and granted charters, one the 'Mines Royal Society', whose privilege it was to work for precious metals and copper in certain areas, and the other the 'Society of the Mineral and Battery Works', who were authorised to get calamine (zinc ore), and to make brass and battery goods (i.e. articles, such as pans and kettles, made from copper or brass beaten into thin sheets). In 1583 copper ore began to be worked in western Cornwall, and as there was no fuel there available, a smelting house was set up at Neath, in South Wales, to deal with the ore. A little later copper ore was discovered at Ecton Hill, Staffordshire and Alderley Edge, Cheshire, and smelting works were set up in the vicinity. The chief essentials of the smelting industry were ore supplies and the availability of fuel. At Keswick peat was used; at Neath charcoal and coal. The brass industry, on the other hand, needed calamine and copper as its raw materials, and power for the hammers, and was best placed near to a market. The first brass works were at Tintern (using the calamine

1. See on this subject H. Hamilton, *The English Brass and Copper Industries to 1800*.

2. Many of the early metal-working establishments owe their foundation not to any geographical advantages possessed by the site but to the settling of a group of foreign artisans.

lately discovered in the Mendips, together with fuel from the Forest of Dean), at Nottingham (using Derbyshire calamine and Staffordshire copper), and on small streams near London (at Isleworth and Rotherhithe). One of the principal uses of brass, apart from 'battery goods', was for wire and pin-making—the chief activity of the Mineral and Battery Society was the production of iron and brass wire for wool-cards.

The political instability of the Civil War and Protectorate period, and the monopolistic control exercised by the two companies mentioned, were unfavourable to great progress;[1] but with the removal of the monopolies in 1689, the way was opened for a considerable expansion in the copper and brass trades, and the improvements in mining and smelting technique which naturally followed, further increased the possibilities of development. During the eighteenth century several areas participated in the general growth of the non-ferrous metal industries. Around Swansea and Neath, the chief activity was smelting, using copper ores imported by sea from Cornwall and Ireland (Co. Wicklow), and silver-lead ore from Cardiganshire. Swansea was at this time the chief port in South Wales—and the nearest to Cornwall—and as it possessed a navigable river, easy access to coal supplies and a large area of flat and otherwise useless land behind it, it offered a very favourable site for the growth of the copper trade. All these advantages were largely shared by Neath. In the Bristol district the ease of the import of Cornish copper ore,[2] the proximity of the Mendip calamine deposits, and the water power provided by the Avon and its tributaries, resulted in both smelting and brass manufacturing. The third region comprises north Staffordshire, northeast Cheshire, and south Lancashire. Here the initial impetus was given by the local copper ores and the calamine of Derbyshire, and the ease of import of copper ore from Ireland. Quite early in the eighteenth century, smelting works were established at Warrington,[3] and copper and brass battery and wire works in the Cheadle district, where water power from the River Churnet was utilised. The greatest development here, however, came after the discovery, in 1768, of a whole hill of copper ore in the island of Anglesey.[4] Although some smelting was done at Amlwch, near the mines, much of the ore was exported; St Helens and Liverpool developed smelting works, and the Macclesfield area took up the brass industry. Considerable quantities of Anglesey ore were also exported to Swansea, where many new works were established. Smelting was tried in Cornwall on several occasions, but none of the attempts really succeeded,

1. In 1670 and again later the copper required for a new coinage had to be imported from Sweden.

2. In 1720 no less than forty ships were constantly employed to carry Cornish ore to Bristol and Swansea.

3. Warrington at that time had just, by the dredging of the Mersey, been made available as a tidal port.

4. The Parys mine quickly became the largest in Europe, and at the end of the century was yielding about 3000 metric tons of metallic copper annually.

principally because of the coal difficulty, but also because the greater part of the British copper-smelting industry was under the control of large combines which could effectively crush any competition from less well organised competitors.[1]

The chief outlets for the copper and brass made were the East India Company, which largely controlled the export trade, and the metal trades of Birmingham.[2] These deserve further comment. In the sixteenth century Birmingham was already a centre of the finished iron industry (see above, p. 453). When brass manufacture first began to develop, early in the seventeenth century, Birmingham was thus a natural market; brass is easier to fabricate than iron, and the skill of the ironworkers could be readily adapted to the use of the new metal. The local demand for brass products was stimulated by the gun, saddlery and harness trades, and the output of buckles, ornaments, and toys increased rapidly after the Restoration. Bad road transport and the lack of navigable rivers made Birmingham specialise in small and valuable goods, whilst the heavy iron trades became localised farther west, where coal and water power (e.g. in the Stour valley) were available, with the navigable Severn not far away. The development of the smelting and brass-making industries at Bristol and Cheadle, together with the expansion of the export trade to Africa and the Indies, gave Birmingham an impetus in the manufacture of metal wares that has sufficed to maintain its supremacy in the trades, even to the present time; and the desire to break the power of the combines (see above) led to the setting up of brass manufacturing (as opposed to the fabrication of brass articles) towards the end of the eighteenth century. Besides Birmingham, Wolverhampton and Walsall also began to develop brass and copper industries; in Wolverhampton the industry grew up primarily as an associate of the lock trade; in Walsall of the saddlery and harness trades.

The eighteenth century witnessed the lead industry at the height of its prosperity. Lead had not been affected to such an extent as the copper and brass trades by the disturbing effects of control by large companies, export and import restrictions, and fashion changes, but, favoured by a flourishing export trade, had undergone a steady development. In Derbyshire the lead miners, most of whom were individualists working for their own ends, and selling the ore from their own small digging or mine to merchant smelters, were governed by laws even more numerous and complicated than the Stannary Laws of Devon and Cornwall; and as most of the mines were small and the laws permitted anyone to dig for lead anywhere, and to remove timber for propping and smelting, the effect on the landscape of the lead mining area lying between Wirksworth and the Peak Forest has been considerable.[3] Other lead mining and smelting regions at this time were

1. Hamilton, *op. cit.*, Chapter 6.
2. *Ibid.*, Chapter 5.
3. J. P. Carr, 'The rise and fall of Peak District leadmining', in *Essays in Geography for Austin Miller*, Reading, 1965, pp. 207–223.

Flintshire, the Leadhills region, the Mendips (though the lead here began to be subordinate to zinc – see below), and the Pennines of north Yorkshire and western Durham.[1] Lead was used for sheeting, pipes and bullets.

The tin mining industry of Cornwall was given a considerable impetus after about 1730 by the growth of the tinplate trade in South Wales (cf. Chapter 17). Despite the commencement of the import of tin ore from the East Indian island of Banka in 1760, this trade, combined with the export market provided by the East India Company, sufficed to maintain the Cornish mines in a state of comparative prosperity. A considerable amount of tin smelting was performed in Cornwall – probably owing to the very early start which the industry had, using peat and charcoal as fuel, and to the fact that unlike the copper trades, tin mining was confined to the one area, and so not subject to competition from better situated producers.

The need of the brass industry for calamine has already been mentioned. In the early days of brass manufacture prepared calamine was used to mix with copper. About the middle of the eighteenth century, however, methods of extracting metallic zinc, or spelter, from both calamine ($ZnCO_3$) and blende ($ZnS$) were discovered, and later spelter was used in brass making. The first zinc smelting works was set up at Bristol in 1743, and thereafter the mining of zinc ores became of still greater importance in the Mendips, where nearly 100 mines were in existence at the end of the eighteenth century.

The outstanding technical developments which influenced metal production in the nineteenth century were concerned with (*a*) more efficient mining methods (i.e. better drainage and ventilation; (*b*) better treatment (washing and crushing) of the ore, so as to get the utmost possible metal out of it; both of these were greatly assisted by the employment of the steam engine; (*c*) improved methods of smelting – the introduction of cupolas and reverberatory furnaces using coal or coke as a fuel; (*d*) the introduction of rolling as opposed to battery in the production of sheet metal. The development of coke smelting and the use of steam power did not, however, as with the iron industry, tend to concentrate the non-ferrous metal industry on the coalfields; for the lean ores were not found in the Coal Measures, and the smelting industry was located either on the ore-fields, as in the case of Derbyshire lead and Cornish tin, or near the coast, where either home or foreign ores could be easily imported, as in the Swansea and Bristol areas and in south Lancashire.

The progress of the non-ferrous metal industries during the nineteenth and early twentieth centuries can be best treated under three headings: ore mining; ore import and smelting; and manufacturing trades.

*Mining.* Taken as a whole, production of non-ferrous ores reached its maxi-

1. A. E. Smailes, 'The lead dales of the northern Pennines', *Geography*, **21**, 1936, pp. 120–9; *Geology of the Northern Pennine Orefield*, vol. i (*Mem. Geol. Surv.*), 1948; Raistrick and Jennings, *op. cit.*, Chs. 6 and 7; R. T. Clough, *The Lead Smelting Mills of the Yorkshire Dales*, Leeds, 1962.

mum during the middle period of the last century, though different ores and different regions reached their climax at varying dates. In the early years of the century, Cornwall and Devon were producing about half of the world's copper ore, but although the actual amount increased until about 1860, the tremendous outputs of Chile and the United States soon dwarfed this into insignificance. The Anglesey ores were gradually worked out, and although between 1850 and 1870 North Wales and the Lake District were fairly productive, a rapid decline quickly set in. In lead mining, the peak period was 1850–70 when the average output was over 91 400 metric tons (90 000 long tons) of ore annually. Derbyshire no longer dominated the industry, the northern Pennines and North Wales producing large quantities.[1] The Cornish tin mines continued to increase their productivity, reaching a maximum between 1870 and 1890, subsequently declining. Zinc mining attained its greatest output in 1881 and declined gradually.

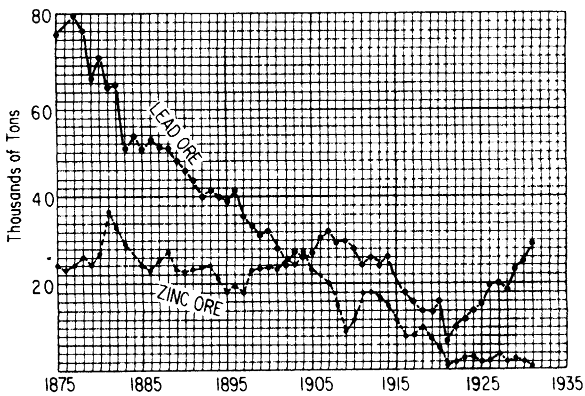



FIG. 181. Lead- and zinc-ore production in Britain, 1875–1931

Since the Second World War, zinc ore has almost ceased to be produced, whilst the output of lead ore has averaged less than 5000 tons a year

The general rapid decline of ore production in the last quarter of the century may be ascribed to several causes. Mining conditions were becoming more and more unfavourable, and the best ores were worked out; prices during the great depression of the 'seventies dropped to ruinously low levels, rendering the working of many mines quite unremunerative;[2] the rapid growth of steam shipping, and the development of large bodies of ore in foreign countries, made for easy import of ores and concentrates—

1. See G. J. Fuller, 'Lead-mining in Derbyshire in the mid-nineteenth century', *E. Midland Geog.*, 3, 1965, 373–93.
2. It should be remembered also that unless pumping is carried on a disused mine quickly gets flooded and the outlay involved in putting it again into working order may be prohibitive.

copper from Chile and the United States, lead from Spain (where it was a byproduct of the silver mines), tin from Australia and Malaya.

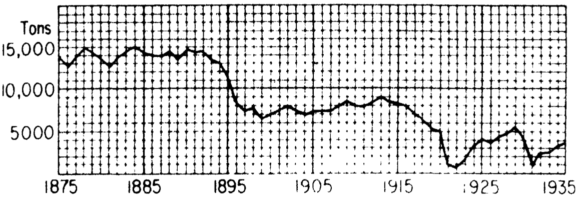



FIG. 182. Tin-ore production in Britain, 1875–1935
Since the Second World War, production has averaged only about 1000 tons a year

*Smelting*. The nineteenth-century smelting industry affords some excellent examples of the results of changing geographical values. The rise of Swansea has already been mentioned. The expansion of the Cornish output of copper ore continued to stimulate the erection of new works on the River Tawe; four (also one at Llanelli) were actually built during the first decade of the century. After about 1830, foreign ores from Cuba and Chile began to supplement the Cornish supplies, and the growth of smelting at Swansea was, as it were, cumulative: the very existence of a number of smelting works, and of a labour supply skilled in metal working was sufficient to

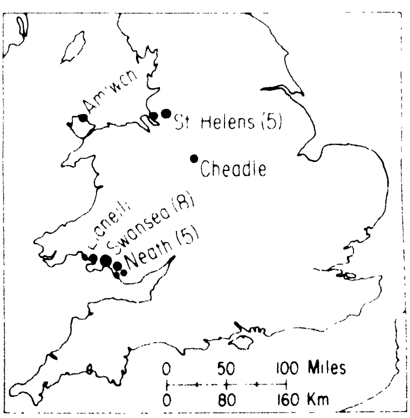



FIG. 183. Copper-smelting works in 1861

attract any new enterprises to the vicinity, and Swansea assumed the position of the world's chief copper smelting centre.[1] In the 1860s, when the trade was at its greatest, Swansea boasted eight copper smelting establishments out of a total of sixteen in South Wales, and twenty-four in the whole

1. See G. Grant-Francis, *History of Copper Smelting in the Swansea District*, and D. T. Williams, *Economic Development of Swansea*.

country. The effect of this vast industry upon the landscape was disastrous. The sulphurous fumes belched forth from hundreds of chimneys during the roasting and smelting operations destroyed the vegetation for miles around, especially on the east side of the Tawe (due to the prevailing westerly winds) and the enormous slag dumps, together with numerous ruined factories, combined to make the entry by rail into Swansea a most depressing journey.[1] The increase of orefield smelting, however, reduced the industry at Swansea to a state when economic competition with Chile, the United States, and Australia was no longer possible and, as a result, from the late 1880s onwards, copper smelting declined until it no longer exists. Instead, smelted copper ('matte' or 'regulus') is imported and refined. The other smelting activities of Swansea (lead and zinc) were formerly of much less importance, but strangely enough they have survived the copper smelting (see below).

The only other copper smelting centre of importance in the nineteenth century (apart from the declining orefield smelters at Amlwch and in North Staffordshire) was St Helens, with the origin of which we have already dealt (Fig. 183).

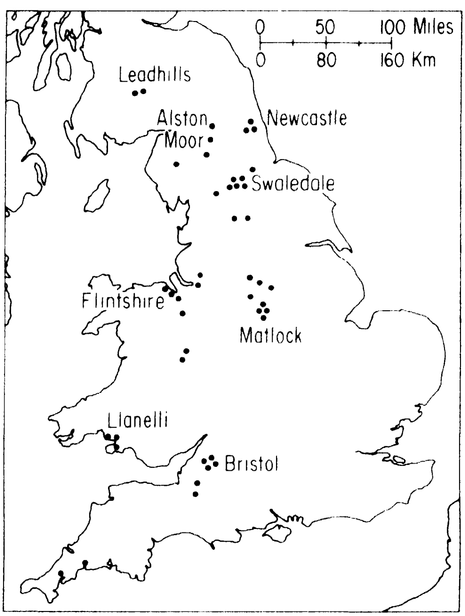



FIG. 184. Lead-smelting works in 1870

The smelting of lead was much more widely distributed, owing chiefly to the fact that rich ores were abundant in many parts of the country, and also to the ease of smelting and the absence of destructive fumes (Fig. 184).

1. The 'Lower Swansea Valley Project' was formed in 1961 to clear up the mess—see K. J. Hilton, ed, *The Lower Swansea Valley Project*, Longmans, 1967.

In Derbyshire (centring on Matlock), in Cornwall, Flintshire, Shropshire, the north Pennines, the Mendips and at Leadhills, the smelting works were located in close proximity to the larger mines. Bristol, also an important centre for other non-ferrous metals, used ore from the Mendips or imported from North Wales. A few works in the Llanelli region used north Welsh ore, and Newcastle upon Tyne smelted ores from Alston Moor, or imported by sea. The rapid decline of mining, however, has considerably reduced the number of works in operation, and the whole of the British lead production is now derived from imported concentrates, which are refined principally at or near the chief seaports.

Although certain of the Cornish tin smelters for a time actually imported East Indian and Australian ore for smelting, the trade has suffered the same fate as the rest of the industry; concentrates are now imported to be smelted at Liverpool or London, and refined tin bars are imported for the tinplate trade.

*Manufacturing.* If, during the nineteenth century, Swansea merited the title of 'metallurgical capital' of Britain (in non-ferrous metals only, of course), Birmingham to an even greater extent deserved to be regarded as the metropolis of those industries concerned with the working of the non-ferrous metals into articles of commerce.[1] The momentum which that city had acquired in the brass and copper trades during the eighteenth century was sufficient to attract any new developments, and so greatly did the market for copper and brass expand during the first half of the nineteenth century that by 1860 brass manufacture was the leading trade in Birmingham. The development of the steam engine had added a vast new market for brass and copper tubes, steam cocks, pressure gauges, etc., and the invention of a method of making seamless tubes in 1838 gave a further impetus to this branch; the introduction of yellow or Muntz's metal for ship-sheathing early in the century, and the demand for 'naval brassfoundry' to which the expansion of shipping gave rise, created a new market; and the increase in domestic and municipal sanitation generated a large demand for taps, water-cocks, etc., whilst gas lighting opened up a new market for pipes and fittings. In 1830 the crucible method of brass manufacture (using copper and spelter) began to replace the old cementation process, and this, like Bessemer's converter in the steel industry, caused a considerable expansion of output, and a reduction of operating costs. Birmingham was, moreover, particularly well situated, following the cutting of canals, for the assembly of raw materials and coal, and was conveniently near to certain accessories of brass manufacture—fireclay crucibles from the Stourbridge district, and local Triassic deposits which furnished excellent moulding or casting sand. It is little wonder, then, that the number of people employed in the brass industry in the city rose from 1800 in 1831 to 8100 in 1861.

1. See G. C. Allen, *Industrial Development of Birmingham and the Black Country*.

It was natural, too, that a city devoted so largely to the working of the baser metals should turn its attention to silver, gold and the jewellery trade. Birmingham began with silver, but early in the nineteenth century gold was being worked as well, and the increasing demand for jewellery in the early years of Queen Victoria's reign, together with the expansion of the gold trade following the 'rushes' in California and Australia in 1849–51, brought about a rapid growth, and by 1860 the jewellery trade was one of the four largest in Birmingham, employing about 7000 people, mostly small craftsmen working in their own workshop-dwellings. The introduction of electroplating about 1840 opened up a vast new market. The silver-plate trade introduced into Sheffield about 1740 had been shared by Birmingham, and the two cities both profited very largely by the great demand which was set up by the cheapening of plated articles without any loss of utility and attractiveness.

To an even greater extent than the brass and copper industries, the jewellery trade depended on foreign raw materials. As a consequence, when competition from better-situated continental and American producers became keen, concentration upon high-class goods became a feature of the trade.

Both the brass and the jewellery trades survived in Birmingham and even expanded considerably, whilst the iron industry was rapidly declining. The cheapening of copper by reason of the huge foreign supplies available, and the vast increase in the use of steam-driven machinery, together with the fact that Birmingham had always been dependent on distant sources of raw materials, and so did not suffer, as in its iron industry, from the disadvantage of failing local supplies, combined to maintain and increase the prosperity of the brass trade. The jewellery industry, augmented by the introduction of jewel-cutting and by the continual increase of electroplating, flourished likewise.

At the beginning of the present century we thus see the various branches of the non-ferrous metal industry very different in magnitude, and in relative importance, though not radically different in geographical distribution, compared with their condition in 1800. Smelting had declined almost to nothing; instead of ores, ingots of semirefined or pure metal were being imported; and the manufacturing industry, helped by the creation of many new uses for the metals, had grown almost out of all recognition, especially in the Birmingham district.

Before dealing with the present condition of the industry, we must glance briefly at the sources of the raw materials; we can then study the distribution of the various branches of the industry and amplify the explanations hitherto given of the geographical factors involved.

*Output of non-ferrous metalliferous ores* (long tons)

| MINERAL | CHIEF LOCALITIES | AVERAGE PER CENT OF METAL IN DRESSED ORE | 1913 | AVERAGE 1921–25 | AVERAGE 1926–30 | 1931 | 1934 | 1937 | 1944 | 1949 | 1955 | 1960 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Copper precipitate[1] | Cornwall, Anglesey | 63 | 163 | 149 | 123 | 109 | 23 | 79 | 27 | Nil | 16[3] | 16[3] |
| Lead ore | Derby, Durham, Cumberland, Dumfries | 80 | 24 282 | 12 048 | 21 583 | 29 502 | 68 122 | 33 411 | 3 969 | 2 465 | 7 443[3] | 1 412[3] |
| Manganese ore | Merioneth, Caernarvon | 30 | 5 393 | 1 214 | 624 | — | — | — | 17 607[2] | Nil | Nil | Nil |
| Tin ore | Cornwall | 60 | 8 355 | 2 195 | 4 566 | 919 | 3 224 | 3 367 | 1 289 | 820 | 1 037[3] | 1 172[3] |
| Zinc ore | Cumberland, Derby, Flint, Dumfries | 46 | 17 294 | 1 696 | 1 913 | 409 | 988 | 13 083 | 8 663 | Nil | 1 048[3] | 250[3] |
| No. of persons employed in all non-ferrous mining (including barytes) | — | — | - | 3 406 | 4 603 | 1 380 | 3 270 | 3 711 | * | * | * | * |

[1] Copper *ore*, 2569 tons, 1913; practically none since 1920. [2] Wartime output only. [3] Metal content. * No comparable figures available.
Apart from 2900 tons of lead ore, no other outputs in 1966 were large enough to be worth recording in the *Statistical Summary of the Mineral Industry 1961–66*, HMSO.

# The present condition of the non-ferrous metal industries

## Home supplies of ore

Some details of the British metalliferous ores have already been given in Chapter 15. It only remains for us to add the table on p. 473, which demonstrates the demise of a once great industry.

*Non-ferrous metal industry: imports of raw material, 1967*

I. Ores and concentrates

| MATERIAL | THOUSAND METRIC TONS | THOUSAND LONG TONS | CHIEF COUNTRIES OF ORIGIN | CHIEF RECEIVING PORTS[1] |
|---|---|---|---|---|
| Bauxite | 458 | 451 | Ghana, Greece France, India | Burntisland, Newport |
| Chromium ore | 99.5 | 98 | S. Africa, Philippines | Manchester |
| Manganese ore[2] | 411.5 | 405 | S. Africa, USSR, India, Brazil | Middlesbrough, Liverpool Manchester |
| Pyrites[3] | 562 | 553 | Italy, Sweden, Spain | Liverpool[4] |
| Tin ore and concentrates | 63.9 | 63 | Bolivia | Liverpool |
| Tungsten ores | 6 | 6 | Bolivia, China | |
| Zinc concentrates | 259 | 255 | Australia, Canada | Swansea, Bristol |
| Lead | 32.4 | 32 | Australia, Canada | Newcastle |

II. Crude metal

| MATERIAL | THOUSAND METRIC TONS | THOUSAND LONG TONS | CHIEF COUNTRIES OF ORIGIN | CHIEF RECEIVING PORTS |
|---|---|---|---|---|
| Aluminium | 228.5 | 225 | Norway, Canada, USA | Liverpool, London, Manchester Newport |
| Copper | 478.5 | 471 | Zambia, Chile, USA | Liverpool, London, Manchester, Swansea |
| Lead | 182.9 | 180 | Australia, Canada S.W. Africa | London, Liverpool, Manchester, Newcastle |
| Tin | 8.1 | 8 | Nigeria, Malaysia | London |
| Zinc (Spelter) | 162.5 | 160 | Canada, Bulgaria, Australia | London, Liverpool, Swansea |

[1] Where no port is given, no port imports in quantities sufficiently large to be recorded separately in Trade Statistics.

[2] Manganese ore is not imported for the production of metallic manganese, but is used in the steel industry; see Chapter 16, p. 394. No further mention will be made of it in this chapter.

[3] Pyrites includes both iron pyrites ($FeS_2$) and copper pyrites ($CuFeS_2$). Iron pyrites is imported for the sulphur and not for the iron.

[4] Many ports receive iron pyrites since its chief use was in gas-works. Liverpool is the chief recipient of Spanish copper pyrites, used in the Lancashire chemical industry (cf. Chapter 22).

## Imports of ores and metals

It is obvious that the small quantities of metal to be obtained from the ores enumerated above could not form the basis of any large manufacturing industry. In order to maintain the vast industries which grew up during the nineteenth century, therefore, recourse must be had to the import of raw materials from abroad. The greater part of the raw material is in the form of crude metal (already smelted and perhaps refined); some ores and concentrates, however (notably zinc from Australia, and bauxite, the ore of aluminium), are still imported by certain ports where the smelting industry, favoured by a coastal situation, is not entirely extinct (e.g. Swansea, Liverpool, Bristol).

Besides continuing their smelting industry, though in a greatly reduced and modified form, these old coastal centres have also turned over to the working up of imported metal into sheets, bars, wire and tubes. But the weight of a given quantity of crude metal will be very little reduced after manufacturing, and in consequence, unlike the ores, this raw material will stand the cost of transport to inland centres. Needing no special accommodation, it can be dealt with to a very large extent by the great ports, London, Liverpool, Manchester, in the course of their ordinary import trade. The large part which these ports play in the import of crude metal is, however, partly accounted for by the existence at all three of important refining and manufacturing industries; but London, especially, imports far greater quantities than its own works can consume, the surplus going to the Midlands or as far afield as South Wales.

*Non-ferrous metals in the United Kingdom* (tons)

| | 1950 | 1960 | 1968 | |
|---|---|---|---|---|
| | LONG TONS | LONG TONS | METRIC TONS | LONG TONS |
| Aluminium | | | | |
| Virgin aluminium production | 29 500 | 28 900 | 38 200 | 37 600 |
| Secondary ,, ,, | 79 900 | 109 600 | 186 000 | 183 000 |
| Lead (refined) production | 73 100 | 91 100 | 143 700 | 141 400 |
| Imported refined lead | 163 400 | 192 100 | 161 400 | 158 900 |
| Zinc (slab) production | 70 300 | 74 300 | 132 800 | 130 700 |
| Home consumption | 330 100 | 365 800 | 367 000 | 361 300 |
| Tin metal production | 28 500 | 27 700 | 28 100 | 27 700 |
| Copper home production | 190 200 | 215 400 | 197 700 | 194 600 |
| ,, home consumption | 526 500 | 722 600 | 779 600 | 668 900 |
| Nickel home production | 20 900 | 33 800 | 41 600 | 41 000 |

## The non-ferrous metal industries considered separately

*Aluminium.*[1] This, one of the most abundant metals in the earth's crust, has given rise to the youngest of the great non-ferrous metal industries. Its de-

1. See W. G. Rumbold, *Bauxite and Aluminium*, Imperial Institute Monographs on Mineral Resources.

velopment dates really from about 1900, with the discovery of a reduction process applicable on a commercial scale. Although alumina is present in all clays, bauxite (a mixture of bohmite $Al_2O_3.H_2O$, and gibbsite $Al_2O_3.3H_2O$), the name derived from Baux in southern France, is as yet the chief commercial source of the metal. The production of aluminium is effected in two stages: (1) by a complicated chemical process, nearly pure alumina (aluminium oxide $Al_2O_3$) is obtained from the bauxite: (2) the alumina is calcined and then reduced in an electric furnace employing a current of great intensity.[1] It is the necessity for electric power on a large scale which has hitherto been the chief obstacle to the spread of aluminium manufacture, and which has caused the concentration of the industry mainly near hydroelectric stations. In Britain, the production of the metal is divided into two quite distinct parts. The extraction of alumina from imported bauxite is effected at Burntisland; the works at Larne which were based on the Antrim bauxites, have been closed, but in 1939 large new works were established at Newport in South Wales. The reduction of the alumina is effected at works using hydroelectricity which have been erected in the Scottish Highlands at Fort William (Inverness) and Kinlochleven (Argyll). Although both Burntisland and Newport, being seaports, are fairly conveniently situated with regard to the import of bauxite it is obvious that a great deal of transport is necessary before the metal aluminium is finally produced; and as the power stations are far removed from the great metal-working centres a further journey is necessary before the metal finally enters the market as a finished article. For this reason it is a great advantage that aluminium is a metal of extreme lightness (Sp. Gr. 2.7).

Something of a revolution in the economic geography of aluminium production was foreshadowed in 1968, however, by Government agreement to the establishment of three large new smelters. The first, at Lynemouth on the Northumberland coast, is to obtain its electricity from a coal-fired power station (part of a conscious effort to boost the coal mining industry); the second, at Invergordon on the Moray Firth, and the third, at Holyhead, will derive their current from the public grid, to which hydro sources from the Highlands will contribute in the case of the former and nuclear power from the Wylfa station in Anglesey in the latter. All three of these new plants are to be located in areas that present special unemployment problems, but the interesting aspect is the breakaway from the apron-strings of hydroelectric stations.

In half a century many uses have been found for aluminium, based mainly on its lightness combined with strength, malleability and ductility, and the ease with which it can be alloyed with other metals. Unalloyed, it is used for electric cable wire (especially the bare overhead lines of the

1. 100 000 ampères at 5 volts, see S. H. Beaver, 'Technology and geography', *Advmt Sci.*, **18**, 1961, 315–27.

Grid and for virtually all low-voltage mains up to 11 kV), in motor-car and aircraft construction, and for hollow-ware (i.e. cooking utensils). Alloyed with copper, zinc, or with two or more other metals, for the purpose of combining lightness with tensile strength, it is used for pistons, cylinders and other parts of aircraft and motor-car engines (as opposed to framework). Two world wars gave a tremendous stimulus to the production of aluminium for aircraft, and the rapid post-1918 expansion of the motor industry provided a new outlet. Aluminium is also employed in the manufacture of the explosive ammonal and the production of metallic paint. The aluminium-manufacturing industry may be divided into three parts: (*a*) Rolling and wire drawing are largely carried on in the metal-working district of southwest Lancashire (Warrington, Prescot, St Helens, etc.); but South Wales, since the last war, has become the major area; at Rogerstone, near Newport, a continuous rolling mill, established in 1950, converts Canadian aluminium ingots into saleable products, while other large plants have been established at Swansea, Resolven (in the Vale of Neath) and Newport. In North Wales, the Dolgarrog hydroelectric plant is concerned with sheet-rolling from imported ingots. An outlying centre, owing its origin largely to cheap land and good rail communications, is Banbury. (*b*) The foundry industry is much more scattered, but its correlation with the motor-car industry is most marked; the most important centres being Coventry, Birmingham (and various Black Country towns), Manchester, the London district and Glasgow. It was natural, considering the importance of the Birmingham-Smethwick-West Bromwich area in the brass and iron-foundry trades, that the first establishment for making aluminium castings should have been set up at Smethwick in 1900. The growth of the industry elsewhere was largely the result of the development of the motor-car and aircraft industries but in later years aluminium has entered into the whole field of general engineering and plays a large part in building (sections and tubing), packaging (aluminium foil), the chemical and food industries (e.g. beer cans) with the consequence that aluminium-using factories are widely scattered. (*c*) The hollow-ware trade, essentially a post-1918 development, is centred at Birmingham, where it is the logical successor of the decayed cast-iron hollow-ware industry.

*Production of aluminium products* (thousand long tons)

| | 1956 | 1968 |
|---|---|---|
| Sheet and strip | 141 | 189 |
| Castings | 79 | 125 |
| Extrusions | 72 | 135 |
| Forgings | 5 | 4 |
| Total | 297 | 453 |
| Total (metric tons) | 301 | 460 |

A flourishing export trade in aluminium products has been built up since the Second World War (see table on p. 486).

*Lead.* With the decline of the home lead mining industry, and the increase of lead smelting at the rich mines of foreign countries, Britain has lost the high position which she formerly occupied in the lead trade. The ores produced in this country now provide less than one per cent of the total lead consumed, the remainder being imported chiefly in the form of pig-lead from abroad (see table on p. 474). To a greater extent than most other metals, lead is used in the production of certain chemical compounds as well as in the metallic state. Of these compounds the most important are white lead, red lead and litharge. They are used in the manufacture of glass, for glazing pottery and earthenware, and for the manufacture of paints and pigments. In the metallic state (when it is soft though tough, flexible and very malleable) lead is made into sheets, pipes, wire and shot; whilst alloyed with other metals it contributes to the production of type metal (lead and antimony), pewter (lead and tin) and certain kinds of brass. Considering this great variety of uses and also the rather scattered nature of the old-time lead industry (cf. Fig. 184), it is not surprising that the manufacture of lead and its products should be much more widely distributed than most of the other non-ferrous metal trades. The last lead-smelting establishments to use locally produced ores were in Derbyshire (near Matlock) and on Deeside in Flintshire (at Bagillt). The establishments on Tyneside which flourished in the days when the Alston Moor mines were at the height of their prosperity have now to rely on imported material; the cessation of Mendip lead mining similarly left the Bristol works without their original basis.

*Production of lead and lead products* (thousand long tons)

| | 1956 | 1968 |
|---|---|---|
| English refined lead | 95 | 141 |
| Imported refined lead | 172 | 159 |
| Lead scrap used | 101 | 106 |
| Lead used in cables | 114 | 79 |
| Lead used for batteries | 28 | 47 |
| Lead oxides and compounds | 72 | 115 |
| Sheets and pipes | 74 | 65 |
| White lead | 10 | 4 |
| Solder | 14 | 14 |
| Alloys | 17 | 20 |
| Total lead used | 358 | 378 |
| Total lead used (metric tons) | 364 | 384 |

The most important centres of the lead industry today are to be found at the ports where the pig lead is received. London, Newcastle, Manchester, Bristol and Glasgow are the most important, but as the raw material is imported in a refined condition, and so leaves little or no waste in manufacturing, numerous inland centres also have works devoted to the manufacture of lead sheets and pipes. Nearly 20 per cent of the pig lead consumed goes towards the making of sheets and pipes, nearly 25 per cent is employed in the production of white and red lead and litharge, and 10 per cent in the making of batteries. The remainder finds an outlet in the manufacture of shot, solder and type metal.

*Zinc.* As with lead, the home production of zinc ores is now almost negligible, and the bulk of the requirements must be imported. In the case of zinc, however, large quantities of ore are imported from Australia, as well as spelter, and smelting is thus still an important side of the industry, with an output of about 100 000 metric tons of metal a year. Consumption was 350 530 metric tons (345 000 long tons) in 1966. The chief uses of zinc are as follows: (*a*) We have already seen its importance in the brass industry, of which, with copper, it forms the raw material—about 32 per cent of the spelter consumed goes towards the making of brass. (*b*) We have examined in Chapter 17 its use in galvanising steel sheets—about 27 per cent of the spelter consumption is employed for this purpose. Wire is similarly given a protective coating; 48 000 kilometres (30 000 miles) of wire so treated were used in the Forth road bridge (1963). (*c*) Lastly, like lead, it has many subsidiary uses—in electric batteries and in the zinco-type printing process, as well as (in the form of various compounds) for the manufacture of lithopone (used in the making of white rubber goods), in the production of pigments and varnishes, in the dyeing and calico-printing industry, and for medicinal purposes. Whilst zinc-using industries are scattered over many parts of the country, therefore, the existence of a large smelting industry, and the necessity for importing spelter as well are bound to have considerable effect upon their distribution.

The smelting of imported ores (i.e. the production of spelter) is carried on in Swansea, where the industry grew up very largely out of the declining copper trade. At first calamine and blende were imported from abroad or from Flintshire, but now the bulk of the supply consists of Australian concentrates. In 1930 smelting both of zinc and copper had practically ceased in Britain. Zinc was produced by only one company—The National (now Imperial) Smelting Company, now a branch of the Rio Tinto Zinc Corporation—which later (1957) developed a new blast furnace system of production at Avonmouth where works had been erected during the First World War. Avonmouth and Swansea are the only smelters. The galvanising industry has two branches: the first, allied to the tinplate trade, deals with corrugated galvanised steel sheets for roofing and fencing purposes (see Chapter 17); the second, with which we are concerned here, is inde-

pendent of the tinplate industry, and is concerned with the galvanising of steel sheets and their manufacture into articles and wares—cisterns, tanks, dustbins, chimney cowls, hollow-ware, etc. It is true that some of the corrugated-sheet manufacturers of South Wales, Bristol and Flintshire also deal in the second branch of the industry, but in the main this trade is concentrated in the Birmingham area and at certain ports. In Birmingham and the Black Country it is an offshoot of the formerly important tinplate trade in an area which deals largely in zinc for its brass industry. At Liverpool, Manchester, London and Glasgow, the localising factors would seem to be (*a*) the port where, in the course of general trade, spelter ingots are most conveniently imported, and (*b*) the presence in the vicinity of a large market for the type of goods produced.

The general working of zinc, apart from galvanising and brass making, is carried on in a large number of towns, but as with most of the non-ferrous metals, the industry is dominated by Birmingham, where over 40 per cent of the firms engaged in the trade have their headquarters.

*Tin.* Tin is not used in nearly such large quantities as lead and copper, the reason being that it does not enter into commerce in the form of articles made of tin, but is employed chiefly in the tinplate industry (to the extent of about 50 per cent of the total consumption), in the manufacture of numerous alloys, such as bronze (tin and copper) (see below) and its varieties—bell metal and gun metal, Britannia metal (tin and antimony, largely used in the manufacture of Sheffield plate) and pewter (tin and lead), and in the formation of a number of useful chemical compounds, used especially in the dyeing and calico-printing industries.

Since the Cornish tin mines, like most other non-ferrous metal mines in Britain, now provide only a very small proportion of the total requirements, a large import of concentrates and metal bars is necessary. The tin smelting industry is located chiefly at Liverpool (Bootle), but there is also a works at Northfleet, on the Thames below London. It is doubtful whether the Cornish smelters at Redruth will ever work again. The annual smelter output of metallic tin is of the order of 20 000 metric tons.

Much of the bar tin imported is consumed in the tin-plate industry of South Wales (cf. Chapter 17). The bronze industry is dealt with below.

*Copper.* Copper was probably the first metal ever adapted by man for his own uses, but its importance in human affairs is now greater than ever before, owing to the part which it plays in the transmission of electrical energy. The valuable properties of copper are its great tensile strength, its ductility, which permits it to be drawn out into the finest of wires, and its capacity for conducting an electric current.

All the copper used in this country now has to be imported, and in consequence the location of the industry is but an interesting reminder of bygone conditions. The early copper industries were founded on such sound geo-

graphical bases, however, that the industrial momentum which they have accumulated has sufficed to maintain them, the only alterations being the substitution of refining for ore smelting, and perhaps some change in the nature of the output.

*Production of copper and copper products* (thousand long tons)

| | 1956 | 1968 |
|---|---|---|
| Refined virgin copper | 118 | 49 |
| Refined secondary copper | 103 | 146 |
| Wire | 259 | 270 |
| Sheet, strip and plate | 131 | 136 |
| Rods, bars and sections | 93 | 113 |
| Tubes | 69 | 86 |
| Castings, etc. | 69 | 59 |
| Total products | 633 | 669 |
| Total products (metric tons) | 643 | 679 |

The smelting and refining of matte (half smelted copper)[1] is carried on in those two regions which were formerly dominant in the ore-smelting industry—southwest Lancashire and South Wales, Widnes and Port Talbot being the chief centres. Birmingham and Walsall also have smelting works. The refining and working up of imported copper bars and their transformation into rolled sheets and wire is an industry located mainly in South Lancashire (Widnes, St Helens, Prescot,[2] Garston (Liverpool))—note the connection with the electrical machinery and cable industries—but several other places, such as Swansea, Glasgow, Hebburn-on-Tyne, Birmingham, Walsall and Leeds, also share in this branch. About 40 per cent of the total consumption of copper is employed in the production of wire, and another 20 per cent in the manufacture of plates and sheets. The manufacture of copper tubes for boilers employs about 12 per cent of the copper consumption. As far back as the 1860s some 8000–9000 metric tons of tubes were being produced annually, and the growth of railways and steamships increased this quantity materially before the end of the century. The use of the superheater and of higher boiler pressures, however, with the employment of steel tubes reduced the demand. On the other hand copper pipes

1. Copper smelting is a more complicated process than iron smelting. The ore is roasted and once smelted to get rid of most of the sulphur (hence the sulphurous fumes mentioned above) and in this stage it is known as 'blister', 'matte' or 'regulus'; a further roasting follows, and then another smelting, when the copper is ready for a final electrolytic refining.
2. A works was opened at Prescot in 1933 for the working of copper of great purity from the Roan Antelope mine in what was then Northern Rhodesia.

have largely replaced lead pipes in domestic plumbing. The tube industry is concentrated almost entirely on Birmingham, where Boulton and Watt first began to produce steam engines on an economic scale in 1775.

Copper is second only to iron as a metal useful to industry, and of the immense variety of articles that can be stamped, pressed, or otherwise fabricated from copper sheets and bars, the electrical and the machinery industries employ the largest proportion. We may expect the 'coppersmith' trade to be located, therefore, with special reference to these industries (cf. Chapter 17) and it is not surprising that, as judged by the number of establishments, Manchester and Glasgow, the two greatest engineering cities in the country, should head the list. London, Birmingham, Liverpool, Sheffield, the textile engineering towns of the West Riding and southeast Lancashire, and the Tyneside towns are also important—but the industry, like general engineering, is on the whole very scattered.

*The Alloys.* Alloys are mixtures of two or more metals designed to give physical properties different from those of the metals which compose them. Some of these have already been referred to. The most important groups are the brasses and bronzes.

*Brass.* Brass is the name given to a whole series of copper-zinc alloys, containing over 50 per cent of copper, the mixing of the metals in different proportions creating new metals of varying properties. Brass, like copper, will take on a brilliant polish, and has a similar high tensile strength, but it is harder than copper. Of the many different varieties in common use, the following may be cited as examples: 'yellow metal' for hot stamping is 58:40 with a little lead; Muntz's metal, a malleable variety, is 60:40; brass for wire 70:30; 'naval' brass 61:38, with a little tin to improve its corrosion-resisting property. It may be as well to remind ourselves of the many ways in which brass enters into commerce and industry. The brass trade falls naturally into two sections: (1) the actual making of the alloy and the production of semi-manufactured material. Of an annual production of something over 300 000 metric tons, about 80 per cent is in the form of rods and sheets (the raw material of the foundry and stamping branches), about 3 per cent is brass wire, and the remainder in the form of tubes (for boilers, curtain rods, and formerly, in the nineteenth century, for brass bedsteads) and castings; (2) the finished goods section, comprising cabinet brassfoundry (locks, hinges, knobs, etc.), lighting (oil lamps, gas and electric-light fittings), plumbers' brassfoundry (taps, etc.), engineers' brassfoundry (steam cocks, whistles, etc.), naval brassfoundry, and a host of general products, such as picture rails and nails.

The brass industry has many times, with changing fashions, been called upon to turn to new activities, and usually the decline of one branch has been accompanied or followed by the rise of another. This has been especially evident during the present century. The declining demand for the

elaborate gas fittings, ornamental candlesticks, brass-railed bedsteads and brass hearth furniture of the Victorian era was offset by the rise of the electrical and motor-car industries, both of which were great brass users, and by the great post-1918 development of housing schemes with their accompanying need for 'builders' brassfoundry'. More recently these brass products have been subjected to severe competition from plastics (see p. 594).

The whole of the brass industry is dominated by Birmingham. At the 1931 census, of 40 000 people employed in the making of brass and brassware, over 16 000 were enumerated in that city, whilst several thousands more were not far away in Smethwick and the Black Country towns. As the table on p. 486 shows, the position in 1950 was almost exactly the same. Outside the Birmingham region, the various branches of the brass trade are very widely scattered all over the country, most important towns, and many quite unimportant ones, having some establishment, possibly a huge factory or possibly only a small workshop, dealing with one or another type of product. Much of the heavy brass industry, together with naval brassfoundry, has migrated northwards to the engineering and shipbuilding centres, leaving Birmingham to specialise on the innumerable smaller foundry and stamped products. Thus whilst Birmingham had only 30 per cent of the brassfoundry workers in 1931, it claimed 62 per cent of the workers employed in the manufacture of light brass goods (builders' accessories, etc.). The rapid development of plastics and stainless steel has had a very serious effect on the latter branch. In 1921 it employed 24 000 people; in 1931 only 12 000. The numerous engineering industries of London employ many brassworkers, and Manchester, Glasgow, Wolverhampton, Liverpool, Leeds, Huddersfield, Sheffield, Rotherham, Newcastle and Bristol—to name only a few—are amongst the most important provincial centres of the brass trade.

*Bronze.* Bronze was the first alloy ever made. Although it is no longer the chief metal for ornaments, utensils and weapons, certain types of bronze still play an important part in industry and art. Bronzes are harder, stronger and more durable than copper or brass, and are particularly resistant to the effects of atmospheric weathering. In industry, bronzes are employed for machinery bearings, pumps, boiler-mountings, valves and cocks, and for parts exposed to damp air or water; and in the arts, bronze is almost unrivalled for beauty of finish and general appearance in the production of statuary and ornaments. In general, bronzes are made up of about 80 per cent copper and 20 per cent tin; gun-metal (so called because it was formerly a favourite material for the making of cannon) has more copper, and more recent varieties which give extra strength and roughness, combined with an even greater resistance to corrosion, are phosphor bronze (containing some lead and a little phosphorus) and manganese bronze (with a little manganese and iron).

The chief centres of the bronze industry are Birmingham and London.

Other towns of importance are Manchester, Coventry and Glasgow (note the correlation with the engineering and motor industries), and Sheffield, where the industry is one of many concerned with non-ferrous metals (especially the rarer ones). The numerous other centres are scattered, and no geographical explanation can be given of them.

*Other metals.* Antimony, chromium, molybdenum, tungsten, bismuth and other rarer metals are imported into this country in small quantities for special purposes—usually for alloying with other non-ferrous metals or with steel. Antimony is used, largely by reason of its hardness and resistance to corrosion, in Britannia metal and type metal; chromium, molybdenum and tungsten are chiefly employed at Sheffield for the production of special quality steels—chromium for rustless steel[1] and steels of high-tensile strength, molybdenum for high-speed tool steels, tungsten for very hard steels (and also for wire in incandescent electric lamps). These metals are refined either at Sheffield, where their subsequent employment lies, or in south Lancashire (Widnes and St Helens). Bismuth has the important property, which it also imparts to its alloys, of expanding when it solidifies from the molten state. When used as a constituent of type-metal it ensures a good sharp type if cast from moulds. The most important of the other metals, however, is nickel. Nickel matte from Canada is refined at Clydach (Swansea), and the resulting metal is employed in the manufacture of nickel-silver at Sheffield and Birmingham, and in the production of nickel-steel, a high-tensile variety, at Sheffield. An interesting byproduct obtained at Swansea is copper sulphate (the nickel matte contains copper) exported to Mediterranean countries for vine spraying and to Ireland for potato spraying.[2]

*The precious metals.* Although gold and silver ores have never been worked in any great quantity in Britain, the unceasing demand for plate, ornaments and jewellery has given rise to a flourishing industry based on imported supplies of these precious metals. In 1966, about 28 000 people found employment in the jewellery, precious metal working and plate trades. To a greater extent than in any other major industry except clothing (see p. 612), these trades are characterised by small firms employing less than twenty-five persons. Such firms in fact produce nearly one-quarter of the products, and employ some 6000 people. This section of the non-ferrous metal industry is far more concentrated on a few localities than any of the trades devoted to the baser metals. Birmingham, Sheffield and London are

1. Notice also the amazingly rapid growth of chromium plating replacing the earlier nickel plating.
2. Production of copper sulphate (average, 1928–31), 44 600 metric tons (44 000 long tons). Export of copper sulphate (average, 1928–31), 43 600 metric tons (43 000 long tons). In 1955–60 the export averaged 33 400 metric tons (33 000 long tons) but by 1966 it had fallen to 13 100 metric tons (13 000 long tons), with Greece as the chief recipient.

the only cities in which the precious metals are utilised to any extent. Avoiding details, it may be said that Birmingham largely controls the refining and beating of gold, and the manufacture of gold chains and other jewellery, whilst silver and the electroplating trades are divided between that city and Sheffield. The Sheffield silverplate industry dates from about 1742, when Thomas Bolsover discovered a method of coating a copper ingot with silver in such a manner than it could be subsequently rolled and worked into plate and ornaments. The growth of the silver and electroplating trades in Sheffield (the latter from 1804) is partly the result of this almost accidental beginning, and is partly, no doubt, to be ascribed to the availability of labour already skilled in the working of metals. Finally, London, largely by reason of its immense potential market, shares in all the chief branches of the gold and silver industry.

## Regional summary

An attempt may now be made to summarise the non-ferrous metal industries according to the regions of Britain where they are carried on.

In 1950[1] nearly 170 000 people were employed in Great Britain in industries concerned entirely, or almost entirely, with non-ferrous metals. This figure differs little from that recorded in the Census of 1931, at which date about 49 per cent were in Birmingham and the Black Country, 16 per cent in the London district, 13 per cent in the West Riding and 8 per cent in South Lancashire.

Although many branches, as we have seen, are very scattered in their distribution, the non-ferrous metal industry as a whole falls, geographically, into a number of fairly well defined provinces, each characterised by the presence of a different series of trades.

The *Birmingham District*[2] is probably the greatest metal-working area in the whole world. Employing nearly 70 000 people, it engages in almost every possible activity connected with non-ferrous metals, from smelting and refining, through the production of semi-manufactured material to the fabrication of innumerable varieties of finished goods. Its specialities, however, are the making of brass, the rolling of brass and copper, and the manufacture of tubes, the production of all kinds of cast and stamped copper and brassfoundry, the working of gold, and the manufacture of gold, silver and electroplated ware, and the production of aluminium hollow-ware.

The *London district*, including lower Thames-side, also has a great variety of metal trades, owing to the facility for importing raw materials and the

1. Later employment figures are on a different basis and not exactly comparable. In 1962 68 000 men and 15 000 women were engaged in the 'manufacture of copper, brass and other base metals'; and in 1966 the total was 80 000.

2. See *Birmingham and its Regional Setting*, British Association for the Advancement of Science, Handbook, 1950, especially pp. 159–248; also M. J. Wise, 'The evolution of the jewellery and gun quarters in Birmingham'. *Inst. Br. Geogr.*, 15, 1949, 58–72.

*Employment in non-ferrous metal industries, 1950*[1] (in thousands)

| REGION | SMELTING, REFINING, ROLLING | BRASS INDUSTRY | JEWELLERY AND PRECIOUS METALS | TOTAL |
|---|---|---|---|---|
| Scotland | 6.4 | 2.2 | 0.2 | 8.8 |
| Wales | 11.0 | 0.4 | 0.5 | 11.9 |
| Northern | 2.5 | 1.5 | 0.0 | 4.0 |
| Northwest | 9.2 | 2.6 | 0.5 | 12.3 |
| E. and W. Ridings | 5.4 | 5.5 | 5.4 | 16.3 |
| N. Midlands | 0.6 | 0.4 | 0.0 | 1.0 |
| Midlands | 37.5 | 21.6 | 10.8 | 69.9 |
| Southwest | 2.7 | 0.3 | 0.0 | 3.0 |
| South | 7.3 | 0.4 | 0.2 | 7.9 |
| East | 2.7 | 0.3 | 0.1 | 3.1 |
| London and S.E. | 13.9 | 4.6 | 10.8 | 29.3 |
| (*London*) | *13.0* | *4.6* | *10.5* | *28.1* |
| Total | 99.1 | 40.0 | 28.6 | 167.7[2] |

[1] Compare table on p. 457, in which the same regional divisions are used.
[2] Compare 1921, 181.6; 1931, 147.5.

*Exports of non-ferrous metals and manufactures thereof* (thousand long tons)

| METAL | 1913 | AVERAGE 1921–25 | AVERAGE 1926–30 | 1931 | 1950 | 1960 | 1968 |
|---|---|---|---|---|---|---|---|
| Aluminium | — | 5.9 | 9.6 | 6.8 | 58.6 | 53.2 | 60 |
| Brass | 13.4 | 26.2 | 21.3 | 12.1 | 55.9[1] | 55.6[1] | 74[1] |
| Copper | 63.4 | 32.3 | 33.7 | 19.4 | 48.7 | 113.4 | 99 |
| Lead | 48.4 | 18.0 | 12.2 | 9.3 | 4.8 | — | — |
| Nickel | — | 4.6 | 7.8 | 4.8 | 13.8 | 26.7 | 45 |
| Tin | 11.5 | 18.8 | 29.3 | 25.0 | 15.4 | 7.8 | 11 |
| Zinc | 11.1 | 6.3 | 6.5 | 6.5 | 5.9 | — | |
| White Metal | — | 6.9 | 4.0 | 3.8 | 3.5 | — | |
| Total value (million £'s) | 12.0 | 14.4 | 17.2 | 6.9 | 57.5 | 89.1 | 168 |

[1] Includes other copper alloys (other than nickel alloys).
1 long ton (2240 lb) = 1.016 metric ton.

extensive market provided by the eight millions of people in the conurbation. Northfleet has important tin and lead-refining works, and London itself, principally in the East End and also south of the Thames, engages in the jewellery trades, sheet-metal working of all kinds, brass and copper foundry, bronze manufacture, galvanising and the manufacture of lead, and lead products.[1]

The *West Riding* assumes a position of importance, largely by reason of the part played by Sheffield in the manufacture of silver ware and electroplated goods. The baser metals are also worked to a considerable extent, however, notably copper and brass—these industries, located mainly in the towns which make up the West Yorkshire conurbation, as well as in Sheffield, being dependent upon and auxiliary to the great engineering industries of that region. The largest copper works is at Rothwell near Leeds.

*South Lancashire* has two sides to its industry. In the western part of the region, at Liverpool, Widnes and St Helens, are located the smelting and refining branches, together with rolling and wire drawing, the chief metals dealt with being copper, tin and aluminium. The eastern part of the region, however, is more concerned with copper and brassfoundry as a part of the great engineering industry of Manchester and the other towns that have been mentioned in Chapter 17.

In *South Wales* we find all that remains of the once world-famous smelting industry. In the Swansea-Port Talbot area are the principal zinc and nickel smelters in the country and the last remnant of the Welsh copper smelting trade. It is a good reflection on the geographical environment of South Wales, however, that just as in the iron trade, few or no derived industries should have been set up. The absence of a great engineering industry has rendered impossible the growth of extensive foundry trades, and even rolling and wire drawing are conspicuous by their absence or feeble development. The aluminium fabricating industry, in the Swansea area and behind Newport, dates mainly from the Second World War and after. The smelting and refining industries at Bristol may be considered, having similar geographical bases, as an outlier of the South Wales province.

The *Northeast coast* still retains its interest in the smelting business, lead and zinc being produced from materials which now have to be imported. The brass and copper industries are largely bound up with the engineering and shipbuilding trades, being concerned primarily with the requirements of the shipyards, and the marine and locomotive engineers.

On *Clydeside* the non-ferrous metal industries are mainly dependent on the engineering and shipbuilding trades, but they also owe their development partly, as at other large ports, to the facility for importing raw materials. Copper and brassfoundry, sheet-metal work, jewellery and galvanising are the most important branches.

1. Billiter Street, in London (bellyeter = bell-founder), was a former centre of the bell-founding trade. London has 300 foundries dealing with non-ferrous metals.

# 19
# The textile industries: woollen and worsted

## The textile industries: general

The textile industries, which for many centuries were the mainstay of British prosperity, are well supplied with literature, technical and historical, economic and geographical. In this and the following chapters little more can be attempted than a summary of the main features of their development, present distribution, and relative importance.

Not only are the textile industries of major importance in employment and in foreign trade,[1] but they also provide interesting examples of the factors influencing the localisation of industry and the alterations in distribution brought about by changes in geographical values. These changing values are concerned primarily with the development of machinery and sources of power supply, and with the relative part played by the various kinds of raw material.

Although wool was from time immemorial the principal fibre employed in the making of cloth, the cotton industry, only introduced into Britain in the seventeenth century and not really important until the second half of the eighteenth, long since surpassed the woollen in size; and whereas the making of woollen cloth, formerly a very scattered trade based on local raw materials and still carried on in a number of different areas, has suffered radical changes in its geographical distribution, the cotton industry, never very widespread and always using imported fibre, has been localised very largely in the region of its origin—so that its recent serious decline has been all the more noticeable. Of the industries based upon the minor textile fibres, those of long standing, such as linen and hemp, show very definite localisation on home sources of raw material. The newer introductions, rayon and nylon, are essentially chemical industries as far as the production is concerned, but their utilisation has attached itself as a satellite to the older textile trades in regions where a 'deposit' of labour skilled in the working of textiles had accumulated.

The introduction of manmade fibres has had a far-reaching influence on

1. Percentage of total value of U.K. exports, 1950 (1913 figures in brackets): woollen mfs, 6.6 (8.0); cotton mfs, 7.3 (25.6); linen mfs, 1.4 (1.9); silk mfs, 2.3 (0.5). But by 1962 exports had fallen to the following totals: woollens £95m (3.0 per cent of total exports), cottons £88m (2.8), synthetic fibres £33m (1.0), silk, flax, jute and hemp £85m (2.7).

the textile industries as a whole, and it is no longer possible—as it was when this book was first published, in 1933—to identify clearly the various branches of the industry, for manmade fibres are spun and woven in what were formerly simply cotton or worsted mills, and are used to produce mixed fabrics of many kinds. Indeed, 'the whole business of yarn and cloth production and distribution is now so enmeshed that the old distinctions in terms of fibres, processes or location are meaningless. The textile industry is one organism and the health of any one member affects the health of the whole'.[1]

Nevertheless, it is impossible to approach the present-day textile industries except through their historical geography, and so Chapters 19–21 have been allowed to retain their titles.

The following tables show the general trends in employment over the last forty years or so. The fact that it is no longer possible to keep to the old classifications is a further indication of the degree of overlap between the various branches.

*Employment in the textile industries, 1924–56* (thousands)

| INDUSTRY | 1924[1] | 1930[1] | 1950[2] | 1956[6] |
|---|---|---|---|---|
| Cotton | 526 | 379 | 326 | 256 |
| Wool and worsted | 273 | 223 | 216 | 210 |
| Fellmongery | 2 | 2 | 2 | —[4] |
| Hemp and linen | 24 | 16 | 14 | —[4] |
| Textile finishing[3] | 108 | 98 | 89 | 96 |
| Canvas and sacking | 9 | 7 | —[4] | —[4] |
| Silk and artificial silk | 40 | 59 | 50[5] | 97 |
| Lace | 17 | 14 | 13 | 10 |
| Hosiery | 95 | 97 | 123 | 128 |
| Total | 1096 | 898 | 1013 | 1007 |

[1] Census of Production Reports. [2] Ministry of Labour figures.
[3] Bleaching, dyeing, printing, finishing. [4] Not available.
[5] Includes rayon and nylon *wearing*; rayon and nylon *production* employed 47 300 in 1950 (cf. table on p. 490).
[6] From Annual Abstract of Statistics.

The decline in the numbers employed in almost all branches continues. This is largely (except in the case of cotton) due to technological improvements that give greater output for the expenditure of less labour. But the employment in manmade fibre production is on the increase, as is that in hosiery (which is now largely concerned with manmade fibres) and in car-

1. Sir Frank Rostron, Chairman of the Textile Council, in *The Times*, 25 March 1968.

pets (in which manmade fibres have also created something of a revolution in recent years).

*Employment in textile industries, 1961 and 1966* (thousands)

| BRANCH OF INDUSTRY | 1961 | 1966 |
|---|---|---|
| Production of manmade fibres | 45 | 51 |
| Spinning of cotton, flax and manmade fibres | 140 | 110 |
| Weaving of cotton, flax and manmade fibres | 130 | 103 |
| Woollen and worsted | 203 | 177 |
| Jute | 18 | 17 |
| Rope, twine and net | 14 | 13 |
| Hosiery and other knitted goods | 130 | 137 |
| Lace | 9 | 8 |
| Carpets | 37 | 43 |
| Narrow fabrics | 22 | 22 |
| Made-up textiles | 45 | 39 |
| Textile finishing | 83 | 71 |
| Other textile industries | 28 | 27 |
| Total, textile industries | 904 | 818 |

*Regional distribution of textile employment, 1966* (thousands) (Ministry of Labour's New Regions)

| | | | |
|---|---|---|---|
| North | 21 | Wales | 18 |
| Yorks. and Humber | 184 | W. Midlands | 37 |
| E. Midlands | 124 | Northwest | 222 |
| E. Anglia | 4 | Scotland | 98 |
| Southeast | 34 | N. Ireland | 53 |
| Southwest | 16 | | |

The above table shows that despite the decline of the cotton industry, the Northwest (i.e. Lancashire) still remains the most important textile province, with Yorkshire not far behind. The figures reflect the continued importance of the East Midlands in knitwear, of the several kinds of textile industries in Scotland, and of linen and manmade fibres in Northern Ireland. The decline of East Anglia from its one-time supremacy is explained in the following pages.

# The historical geography of the woollen and worsted industries[1]

From the twelfth to the nineteenth century the woollen industry was the premier English industry, and as such was largely responsible for the growth of the country's wealth and so for the accumulation of the capital which rendered possible the development of the homeland and the Empire. Thus the existing industry is but the result of many centuries of development in which geographical factors have played a very large part.

## From the earliest times to the fourteenth century

It is probable that a primitive domestic woollen industry existed even before the Roman occupation, and it is certain that cloth was made in Britain during that period, for the Romans had an establishment at Winchester for making fine uniform cloths, and evidence of dyeing and fulling operations has been found at various places in southern England. Spinning and weaving are occasionally mentioned in Anglo-Saxon literature, and it is possible that woollen fabrics were being exported to the Continent as early as the eighth century. Not until after the Norman Conquest, however, do we see definite evidences of the growth, helped probably by the skill of artisans amongst William's followers and by numerous refugees from continental wars, of a flourishing industry. This industry in the twelfth and thirteenth centuries was to be found principally in the larger towns of the southern and eastern parts of the country, which, largely owing to their accessibility from the continent and from the Metropolis, were at that time the seat of the chief economic developments. The earliest recorded weavers' guilds, for example, grew up in London, Winchester, Lincoln and Oxford, and other towns which gained a reputation for fine wares were York, Beverley, Colchester and Sudbury. Although the making of cloth was widespread, the industry was probably of no great magnitude, and most of the wool from the English sheep was exported in a raw state to the Continent.

## The first economic revolution, fourteenth to sixteenth century

Having reached a peak of production and export in the thirteenth century, the wool trade declined for a long period; the almost incessant political strife was not conducive to its expansion, and many formerly important centres decayed. The seeds of a new period of progress were sown in the fourteenth century, however, when, from 1331 onwards, small bands of

1. Of the mass of historical literature, one of the most valuable items is E. Lipson, *History of the English Woollen and Worsted Industries*, 1921 (especially Chapter 6). The descriptions to be found in Leland's *Itinerary*, Fuller's *Church History*, and Defoe's *Tour through Great Britain* are exceedingly interesting and valuable as giving an account of the distribution and state of the industry at the different periods when they were written.

skilled craftsmen from Flanders were encouraged to settle in various parts of the country. Numerous weavers, dyers and fullers settled in large towns where the woollen industry was already in existence—such as London, York, Winchester and Norwich—or scattered themselves over the countryside. The widespread possibilities for cloth making were largely due to the suitability of such large areas of the countryside for sheep rearing (although from the earliest times the drier limestone and chalk uplands seem to have been the chief regions), and the absence of other localising influences. Water-mills were only just coming into use for working the fulling hammers,[1] and not only was the power required so small that almost any stream would do, but the unfinished cloth could be, and indeed was, sent from scattered weavers' houses to the small streamside establishment of the fuller.[2]

The export trade in wool recovered; it was largely a seasonal trade, for before the introduction of root crops as fodder, large numbers of animals had to be slaughtered in the autumn. Thus in the summer the shorn wool was sent across the Channel, in the autumn and winter the 'fells'—skins with wool still adhering thereto. But manufacturing expanded as well, and gradually the cloth industry began to be more localised and rather more specialised. The need for soft, lime-free water for the washing, scouring, and dyeing processes, combined with the increasing use of water power for the fulling mills, resulted in certain regions offering a more than usually favourable environment for the industry. In Gloucestershire, Somerset and Wiltshire, the importance of the sandstone formations in the Jurassic series, as suppliers of soft water, and the existence of a dissected scarp, providing numerous power sites, together with the extensive sheep pastures on the Cotswolds and in Herefordshire, were favourable factors. In Devonshire a number of centres grew up on the outer edge of the Dartmoor mass, favoured by soft water from the granites or culm measures and a useful power supply. In the Pennine districts of Yorkshire and Lancashire the soft water from the Millstone Grit uplands and the numerous steeply graded streams gave plenty of scope for development. In East Anglia, where many of the Flemish weavers settled, much soft water was available from the boulder clay streams, but little or no power. As a result, this region was not so well fitted for the production of true woollen goods, and came early to specialise in the manufacture of worsteds.[3] The idea of the fulling operation was to felt the cloth by pounding it with hammers in water mixed with soap or fuller's earth, and as worsted fabrics made from longer and finer wools did not require this treatment, power was not necessary. Of these four areas

1. R. A. Pelham, 'Distribution of early fulling mills in England and Wales', *Geography*, **29**, 1944, 52–6.
2. The need of pure water for dyeing was not apparent whilst most of the cloth was exported in a 'grey' state to be finished in Flanders.
3. It is generally agreed that the name 'worsted' is derived from the little village of Worstead, not far from Norwich, one of the earliest centres of the industry.

the two in the west of England were producing, at the end of the fifteenth century, about one-third of the woollen cloth made in England, East Anglia was responsible for about a quarter and Yorkshire for one-eighth (mainly of poor quality), and, in addition, East Anglia produced almost all the worsted material. Finally, it is very noticeable that the sheep-rearing regions of the Jurassic scarplands where limestone is a dominant formation and the stream water consequently hard—e.g. Lincolnshire and Northamptonshire—did not develop the manufacture of woollen fabrics to any great extent.

Thus during this period the whole economic outlook of the country was changed, and from being primarily an exporter of raw wool England became in addition a manufacturer and exporter of cloth. The end of the fifteenth century saw England 'largely a nation of sheep-farmers and cloth-makers'. The wealth derived from the wool trade was spent in church building and road-making, and many a fine church and cathedral and many a now-ruined abbey owes its origin to the sheep. The monks especially were great sheep farmers, as the records of the many old abbeys of Yorkshire bear witness.

## Growth and expansion, sixteenth to eighteenth century

The expansion of the woollen and worsted industries brought about an increasing specialisation: (*a*) of different regions in different classes of goods; (*b*) of individual members of a manufacturing community in different processes; and it also contributed to the rise of a new class in society—the 'clothiers' or 'drapers' who purchased raw wool from the farmers, gave it out to the spinners and weavers to be made into cloth, and then sold the finished pieces in local markets or at the London Cloth Fair.[1] Much of the wealth gained by the drapers, and by the companies which they formed, went not into ecclesiastical channels but towards the further expansion of industry and trade. Then political and religious troubles on the continent were continually interfering with the Flemish cloth industry, and from time to time bands of refugees would flee their country and settle in England. In the sixteenth century, for example, after the revocation of the Edict of Nantes, a large body of Huguenots arrived from France and took up their abode in various cloth-making regions, notably in the Stroud area of Gloucestershire. As a result, the English cloth trade began to surpass that of Flanders, and at the end of the seventeenth century woollen manufactures made up two-thirds by value of England's export trade.

We must pause to analyse in a little more detail the geographical background of the principal centres of the industry in the seventeenth and early eighteenth centuries.

1. The markets were known as 'Cloth Halls'—e.g. Blackwell Hall in London.

*The West Country.*[1] Within the region so designated there were two distinct producing districts, the Cotswold area (extending from Cirencester to Sherborne, and from Devizes to Bristol), and Devonshire. In Gloucestershire, Wiltshire and part of Somerset was concentrated the manufacture of the famous 'broadcloths', while Devonshire and southwestern Somerset specialised in serges. The geographical advantages possessed by the region as a whole may be summed up as follows:

(*a*) The agricultural wealth of the fertile vales and the pastoral wealth of the uplands had long been utilised and had given rise in quite early times to a comparatively dense population.

(*b*) Supplies of raw materials—long-woolled sheep of Dartmoor and the Cotswolds (for the serge industry), short-woolled sheep of the near-by chalk uplands and the rich lands of Herefordshire, of the Forest of Dean and of Exmoor, and fuller's earth from the local 'Fuller's Earth' formation, which is particularly well developed on the dipslope of the Cotswolds—were present in abundance.

(*c*) When the necessity arrived, the geographical situation for the import of foreign wool was distinctly favourable—and Barnstaple and Bristol imported long wools from Ireland and fine merino wool from Spain.

(*d*) The abundance of soft water,[2] which was particularly suitable for dyeing, and of small water-power sites, as mentioned above, rendered the localisation complete.

Broadcloth was, perhaps, the finest variety of woollen fabric ever produced. It was made from the best short wools (i.e. not from the local Cotswold sheep) and was heavily fulled and felted so that when finished the weave was quite invisible. It was used for uniforms, liveries, and the best class of clothing. The wearing of broadcloth was formerly the mark of a gentleman. The importance of a power supply for the fulling is very evident, and it is not surprising that with the growth of the industry the localisation became more definite, and the network of 'clothing towns' and 'clothing villages' which Leland describes became more concentrated. The early town centres, Gloucester, Bristol and Tewkesbury, soon declined, and the less suitable outlying centres as, for example, the villages along the chalk scarp (Devizes, Warminster); those on the Mendip fringe (Frome, Wells); those on the Jurassic scarp of Somerset (Bruton, Castle Cary) and those in the Avon valley (Chippenham, Melksham, Bradford) decreased in importance or became specialised. Wells, for example, took up the hosiery trade; Frome specialised in fine Spanish cloths. It was on the dissected west-

1. See R. H. Kinvig, 'Historical geography of the West Country Woollen Industry', *Geographical Teacher*, **8**, 1916, 243–54; 290–302.

2. Although much of the Cotswold dipslope plateau is composed of shelly limestone (known as 'calcareous grit'), the chief water-bearing bed in the Scarp region is the Cotswold (or Midford) Sand, which yields copious supplies having a very low degree of permanent hardness.

facing scarp of the Cotswolds that the industry became concentrated, and the old centres on the dipslope—Tetbury, Cirencester and Witney—all had to specialise to avoid extinction. Thus Tetbury, devoid of water power (almost, in fact, devoid of water), took up wool-combing and spinning, and Cirencester did likewise—thin yarn from the long-woolled Cotswold sheep being sent to the hosiery and worsted centres. Witney, partly perhaps owing to a peculiarity of the Windrush water which makes it well suited to the bleaching operation and partly to the fact that it had little or no power, specialised in blankets, which are made from short wool and fells and do

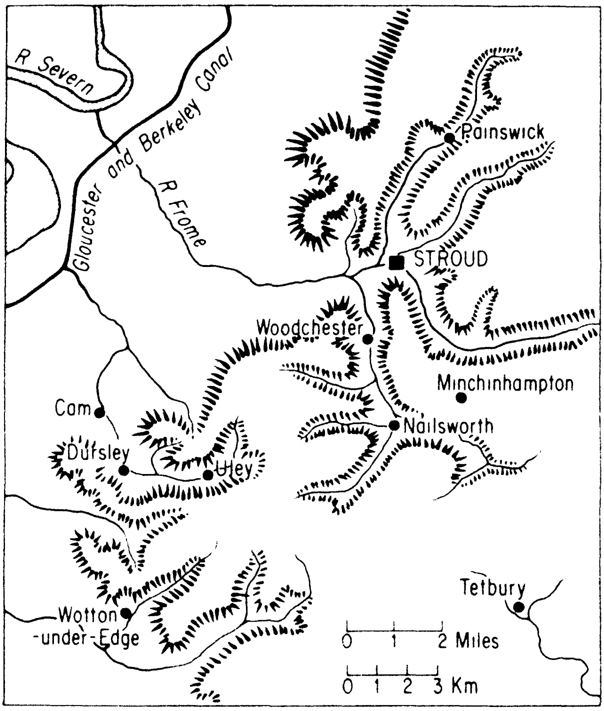



FIG. 185. The Broadcloth region in the dissected scarpland of the Cotswolds

not need heavy milling. On the western slope of the Cotswolds the deeply cut valleys of the Frome and its tributaries contained numerous centres of the industry—Stroud, Painswick, Minchinhampton, Woodchester and Nailsworth, and a little further south the edges of a westerly projection of the scarp provided power sites, for example, at Dursley, Wotton-under-Edge and Uley (Fig. 185). The waters of the scarp were considered to possess some property which rendered them particularly suitable for the production of the fine scarlet dye for which Gloucestershire cloths were famed.

'Serge' was the name given to a fabric made with a warp (longitudinal

threads) of long wool, and a weft (crosswise threads) of short wool (or of the short combings derived from the long wool). Both long (Dartmoor) and short (Exmoor) wools were available in Devonshire, and in addition much long Irish wool was imported *via* Barnstaple and other ports, and short wool

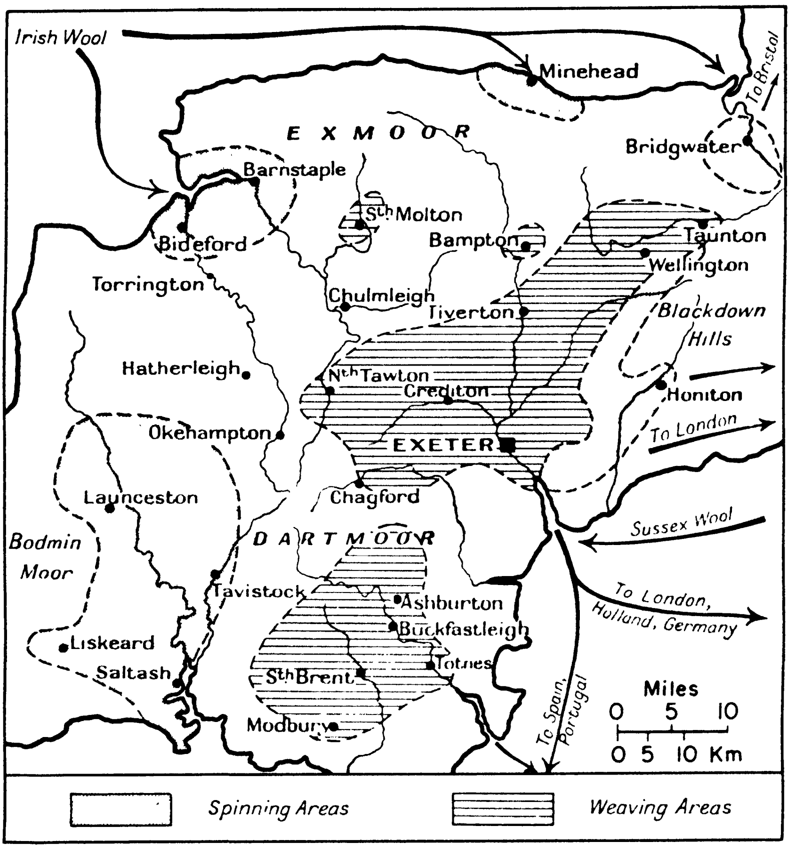



FIG. 186. The West Country woollen industry about 1700 (mainly after Hoskins)

from Kent and Sussex, *via* Exeter. Water power was necessary for milling serges, as for broadcloths, and the numerous small streams radiating from the Dartmoor massif supplied this in plenty. But owing to the comparative isolation of the individual streams many small manufacturing centres grew up, and there was no concentration as at Stroud. Ashburton, Buckfastleigh, Tavistock, Okehampton, North and South Molton, Tiverton and Crediton may be cited as examples, whilst just over the border, in Somerset, Taunton and Wellington were also engaged in the serge trade (Fig. 186). The great

market for all this industry was Exeter, which in the eighteenth century rivalled Leeds in this respect.[1]

*East Anglia*, lacking water power, obviously could not produce broadcloths and serges, and in consequence it was the worsted trade which flourished here. The worldwide fame to which this region attained in the seventeenth and eighteenth centuries was in large measure due to the presence of the Flemish weavers and their descendants—far more artistic skill was necessary for the production of patterned worsteds than for the making and finishing of plain broadcloths. Two separate districts were engaged in the trade. Norwich, once the greatest manufacturing town in all England,[2] was the centre of a whole group of flourishing towns and villages engaged in the production of fine worsteds: for example, Thetford, Diss, Dereham and Attleborough. In Suffolk and Essex a number of towns in or near the Stour valley, the largest of which were Colchester, Sudbury and Halstead, had a twofold interest. Besides making some worsteds, and doing a great deal of combing and spinning for the Norwich weavers, this region, largely owing to the presence of a small amount of water power provided by the Stour and its tributaries, was devoted to the production of coarse cloths made from short wools—baize and kerseys, which were not true woollens, but rough loose fabrics which did not need much milling.

For 400 years East Anglia possessed a virtual monopoly of the worsted trade, and not until the beginning of the eighteenth century did a rival appear in the West Riding of Yorkshire.

*Yorkshire and Lancashire.* The gradual rise of the north country in the woollen trade is to be associated with the natural suitability of parts of the Pennines for sheep rearing, the abundance of lime-free water, and the existence of innumerable possible sites for waterwheels. The sixteenth-century spread of the industry up the valleys was also due to a countryward movement of the craftsmen away from the guild fettered corporate towns of the lowlands.[3] We must not neglect the fact, also, that a good deal of energy behind the expansion of the industry came from the Nonconformists, whose Puritanism, with its insistence on the duty of work, its teaching that business could be a 'divine calling', and its inculcation of the virtues of prudence, probity, and economy which smoothed the path to riches, was largely responsible for their accumulation of capital and its application to the development of trade. In both Lancashire and Yorkshire the early industry, devoted to the

1. See W. G. Hoskins, *Industry, Trade and People in Exeter, 1688–1800*, Manchester Univ. Press, 1935. Chap. 2 gives an account of the serge industry, which about 1700 was the most important branch of the national woollen manufacture, accounting for over a quarter of the total exports.

2. In 1770 no less than 72 000 people were employed.

3. Of the great West Riding towns, only Wakefield ever harboured the guild system. The serious decline of York at this period is well known.

weaving of coarse woollen cloths called 'kerseys', clung to the upper parts of the valleys, the dwellings where the spinning and weaving were done being situated on the slopes and higher parts (since surface water is very abundant on the Millstone Grit formation and Lower Coal Measures), the fulling mills in the valley bottoms by the larger streams. It was essentially a rural organisation—a combination of domestic industry and agriculture for the home food supply, where each house had its own cultivated patch and urban centres were not developed to any great extent.[1] The industry quickly outgrew the local wool supplies, and the Lancashire region began to import from Ireland and from the Midlands, while the West Riding came to rely more on Lincoln and Leicester wool. About the end of the sixteenth century, the manufacture of baize (using woollen warp and worsted weft) was introduced; but as the use of cotton began to spread soon afterwards in south Lancashire, the woollen trades in that area were pushed further and further eastwards until the Rochdale neighbourhood was the only important district remaining. Then, early in the eighteenth century, the wealthy merchants began to introduce the manufacture of worsted material, and Halifax and Rochdale quickly took to the making of 'shalloons' (light worsted cloth for dresses and linings)—the older baize trade gradually dying or being replaced by the weaving of flannels. By the 1770s the output of worsted cloth from the West Riding equalled that of Norwich, but the Yorkshire worsteds were mostly of much poorer quality.

An important auxiliary industry in the West Riding was the manufacture of wool-cards—stiff wire brushes used for opening out the wool and interlacing the fibres preparatory to spinning.[2] This was located at Brighouse—attracted thither by the old iron forge at Colne Bridge (near the outcrop of the sulphur-free 'Better Bed' coal and near a formerly important seam of ironstone).

In the eighteenth century the main outline of the great conurbation was complete; Leeds, Bradford, Halifax, Huddersfield and Wakefield were flourishing towns, Leeds and Wakefield having large cloth markets. Bradford had, however, not yet assumed special prominence, and neither had the shoddy trade (see p. 514).

*Other centres.* Mention must finally be made of a few other isolated and rather specialised centres of the woollen industry. Worcester and Kidderminster were really outlying centres of the West Country broadcloth trade. Kendal, in Westmorland, was long famous for 'Kendal cottons' (not made from cotton, but from local wool). In Leicestershire the local long-woolled flocks gave rise to a small woollen industry as early as the thirteenth century; and in the seventeenth century a domestic hosiery industry became established.

1. See the illuminating description in Defoe's *Tour through Great Britain*, which covers the years 1724–27.
2. The name 'card' is derived from Latin *carduus* = a thistle or teazel, since teazel heads were used in the carding process.

In the first half of the eighteenth century we thus see the woollen and worsted industries considerably more specialised and concentrated upon a few areas than they had ever been before. The West Country and East Anglia had almost reached their peak of prosperity, but the West Riding was really only just beginning to be of real importance in the manufacture of any but the poorest cloths. All this was about to be changed, for with the introduction of machinery and the utilisation of steam power and so of coal, the whole basis of the industry was radically transformed.

## The Industrial Revolution, 1750–1850

The domestic processes of cloth manufacture had been little changed since the great revival of industry in the fourteenth century, and consequently the inventions which we have now to discuss produced an upheaval of unparalleled magnitude. This upheaval, however, took place earlier and was far more sudden in the case of the Lancashire cotton industry than with the Yorkshire woollen and worsted trades: in the first place because almost all the inventions emanated from Lancashire; secondly, because the woollen fibre did not lend itself so readily to being worked by fast-moving machinery; and thirdly, because an adequate supply of raw wool was not easy to obtain until Australian produce became available after about 1830. The history of these inventions is an oft-told tale, and a very brief summary must here suffice. In 1733 John Kay introduced the flying shuttle, thus rendering the process of weaving rather more rapid. This was perhaps a little unfortunate, for already it took ten spinners to keep one weaver supplied with yarn (a fact which is reflected in the large number of women who were engaged in spinning—and thus in the retention of the term 'spinster' for an unmarried woman); in the 'seventies, however, Hargreaves' spinning jenny and Arkwright's roller-spinning machine remedied this state of affairs, and the application of water power to the latter resulted in such an increased output that a surplus of yarn was produced. The application of mechanical power to weaving was somewhat delayed (see below). All these inventions were applied first to the cotton industry and their adaptation to wool and worsted came later. As a result the 'water power' stage in the West Riding was not of long duration and in some cases did not exist at all—for by the time machinery was introduced on a large scale, the steam engine had been sufficiently perfected as to be the obvious source of power for new mills and new machines. A new control—the existence of productive coal measures—entered the field.

The Lancashire inventions gradually crossed the Pennines and worked their way into the West Riding from the southwest, *via* Huddersfield and Halifax and probably by 1780 the use of the spinning jenny, still worked by hand, and of the scribbling machine (performing part of the carding process), worked by water power, had spread over most of the region. Neither of these could produce much change in the industry apart from a speeding up of certain of its processes—and by the separation of the upland, domestic,

spinning and weaving from the valley-bottom scouring, fulling, and carding, much wasteful carriage had to be performed, each piece of wool journeying several times up and downhill before it finally emerged as a finished cloth. From 1785 onwards Watt's steam engine began to be used in the mills of Lancashire and Nottinghamshire, and the first in Yorkshire was set up for driving scribbling and fulling plant at Leeds in 1792[1]—marking the beginning of the end of the short reign of water power. Spinning machinery was introduced into Yorkshire in the 'nineties, and was in fairly general use by about 1810—the quick changeover being due possibly to the large numbers of women and children employed who were unable, like their menfolk, strenuously to resist the introduction of mechanical appliances. It must be noted, however, that it was the worsted branch, in which the longer, silkier fibres were more adaptable to mechanical handling, that progressed most, little headway being made with spinning machinery in the woollen branch until after 1830. Other, more commercial, reasons for the greater mechanisation of the worsted industry, were the greater capitalisation and more efficient organisation (it being a younger industry and essentially the product of Yorkshire's own accumulated wealth) and the large 'outside' demand (from the East Anglian worsted trade and the hosiery trades) for worsted yarn. The introduction of power looms took a much longer time, partly owing to the technical difficulty already alluded to and partly owing to vigorous opposition from the hand loom weavers. Not, in fact, until the early 'thirties was real progress made, but by 1835 Yorkshire possessed over 4000 woollen and worsted power looms out of a total for the country of about 5400 (a further 1100 being only just across the Pennines in Lancashire).[2] Gig mills (rotating drums set with teazels for raising the nap on cloth) and shearing frames (for cropping the nap) were also introduced fairly late, and the famous Luddite Riots of 1812 were largely directed against their use. In the following decade, however, they were erected rapidly in all districts.

Even when, stimulated by the outstanding success of the mechanised cotton industry of Lancashire, the use of machinery was well established, wool continued to lag far behind worsted for reasons given above, and also because there was much less specialisation in the woollen trade, most factories completing all or most of the processes, and a considerable amount of domestic work still taking place. In 1835 the number of looms weaving worsted cloth was four times the number weaving wool, and as late as 1856 only half of all the woollen workers in the West Riding were employed in factories, and handloom weavers remained an important section until the 'seventies, not being finally negligible until about 1900.[3]

1. See *Leeds Woollen Industry, 1780–1820*, ed., W. B. Crump, Thoresby Society, Leeds, 1931.
2. Compare this total with the 114 000 power looms which existed in the cotton industry at the same period.
3. Persons employed in woollen and worsted factories: 1835, 55 461; 1850, 154 180; 1861, 173 046; 1870, 238 503; 1880, 301 556; 1901, 259 909. Cf. cotton, pp. 532–33.

If the introduction of machinery was slow, though comparatively unobstructed, in the West Riding, it was much more retarded and much more bitterly opposed in the West Country, and in East Anglia the industry died before the machine had time to take root. Both in the West Country and in East Anglia the workers in the ancient industries were well organised and the industry was fairly concentrated, and so a much more effective opposition could be raised to the introduction of labour-saving machinery. This opposition proved their undoing. The swamping of the cloth market by cheap machinemade goods from Yorkshire gave a blow to the older industries from which they never recovered. The copying by machinery of all the fancy worsted designs of Norwich effectively killed the trade in that town. By 1830 domestic spinning had ceased to exist, and in 1838, when Yorkshire had 347 steam-driven mills employing over 26 000 people, Norwich had three with only 385 workers. The perfection of Arkwright's combing machinery had allowed short wools as well as long to be used for worsted manufacture, and the rapid spread of new fabrics produced by adding cotton, alpaca, or mohair warps to the worsted weft gave a tremendous stimulus to the Yorkshire worsted industry, which rapidly outpaced the slower growing woollen trade.

The West Country industry did not feel the pressure of Yorkshire competition as soon as East Anglia, owing to the late introduction of machinery and steam power into the woollen branch and to the persistence of the domestic system. After 1840, however, the declining market for the fine broadcloths and the inability of the Cotswold industry to adapt itself rapidly to the new conditions resulted in a period of decline—though the industry was by no means completely extinguished.

The general features of the Industrial Revolution period in the woollen and worsted industries may be summed up as follows:

(*a*) A gradual decline of the domestic system, less rapid in wool than in worsted, and in weaving than in spinning: accompanied by the development of large-scale production in factories.
(*b*) A short period of water power quickly followed by the employment of the steam engine for driving machinery.
(*c*) The rapid expansion of industry in the West Riding, where the localisation was confirmed by the presence of coal which was employed for generating power and for heating and humidifying the mills in accordance with the requirements of the spinning and weaving operations.
(*d*) The rise to supremacy of worsted over woollen in Yorkshire, very largely for technical reasons and owing to the organisation of the worsted industry.
(*e*) The decline and complete extinction of the Norwich worsted trade and the general decline of the West Country industry, where, however, with increasing specialisation the finest woollen cloths continued to be made.
(*f*) The growth of the West Riding, in combination with the rapid ex-

pansion of industry and population in Lancashire (see Chapter 20), brought about a change in the 'centre of gravity' of the English population and an increasing dominance of the north over the south.

### Concentration and development, 1850–1950

The essential features of the geography of the woollen and worsted industries remained virtually unchanged for a century following the great transformation wrought by the Industrial Revolution.[1] Despite the great increase in the productivity of the industries there was little expansion after 1850 in the numbers employed, which fluctuated around 260 000 until the 1920s; this of course was due to the increased mechanisation of the processes of manufacture, to the greater concentration in large mills, and to the improvements in speed and efficiency of the machines. After 1900 there was a gradual tendency for steam power to be supplanted by electricity. There were, however, substantial changes in the supplies of raw wool. In the few decades before 1850, about three-quarters of the wool used was home grown, the remainder being fine Saxon and Silesian varieties. Between 1830 and 1860 Australian and Cape wools began to display all other imports, and with the expansion of the industry the home clip came to assume a less significant position, declining to about one-tenth of the total quantity used (see table on p. 505).

## Raw materials

The raw materials of the woollen and worsted industries consist principally of the wool of the domestic sheep, which is the most important of all fibres of animal origin used in the textile industries. There is no wild sheep with a fine fleece, and the sheep—now the most numerous of all domestic animals—was bred by man at an early date in the civilisation of the world. Even before the wool was used in weaving, sheepskins formed a valued protective covering. The fibres of wool differ from those of cotton in being covered with tiny overlapping scales, and the presence of these scales accounts for the 'felting' properties of wool: the fibres can be beaten together into a fabric (felt) without weaving because the scales interlock. It is because the fibres of wool are usually finely curled or crimped that a woollen cloth includes a large proportion of air space. Air is a bad conductor of heat and thus woollen clothes, with their large amount of included air, are very warm.

Without attempting to account for their origin, it may be said that wool-bearing sheep at the present day fall into three main groups:

(*a*) *Original English breeds*. In the Middle Ages wool was not only an im-

1. A useful summary will be found in the Board of Trade's *Survey of the Textile Industries*, HMSO, 1928.

portant product but a leading export of England. The English breeds have become widespread in South Africa, Australia and New Zealand. The animals thrive in cool, comparatively moist climates.

(*b*) *Merino sheep.* These sheep are natives of North Africa, but were introduced into Spain and other grassy areas in Mediterranean lands in the Middle Ages and later into Saxony. They yield but very poor meat and are bred essentially for their wool. They have become very important in South America, South Africa, Australia and New Zealand. The animals thrive in dry climates.

(*c*) *Cross-bred sheep.* These sheep are derived from cross-breeding between merinos and English strains. A large proportion of the Australian and New Zealand flocks are cross-bred. Cross-bred sheep yield both meat and wool.[1]

Shearing by machinery is now usual at most large sheep stations, and as the quality of the wool varies considerably from one part of an animal to another, the fleeces are usually clipped round or 'skirted', the inferior clippings being thrown into a separate bin. According to the age of the animal four grades of wool are distinguished:

*Lamb's* wool from 7 months old animals—the finest.
*Hoggets* from 12 to 14 months old sheep.
*Wether wool* from sheep of all other ages.
*Double fleece*, representing two years' growth, is poorer in quality than a single-year fleece from the same animal and is cheaper.

Fleeces vary greatly in weight. Australian sheep average between 2.5 and 3.1 kilograms (5½ and 7 lb); New Zealand sheep 3.4 kilograms (7½ lb). A prize fleece may be as much as 13.5 or 18 kilograms (30 or 40 lb).

Wool is graded according to the 'count' or number of 512-metre (560-yard) hanks that weigh 0.45 kilogram (1 lb).

*Fine counts*, from 60 to 90 hanks to 0.45 kilogram (1 lb). These are chiefly merino wools and are short stapled (6.35 to 15.2 centimetres (2½ to 6 in)).
*Medium counts*, from 36s to 60s. These wools are usually long stapled (up to 30.4 centimetres (12 in)) and include the wools of English breeds and the cross-bred colonial wools of South America and Australia.
*Coarse or low counts*, below 36s. These wools are more like hair, and include the wools of southern Russia, Asia and North Africa.

Wool as shorn from the sheep contains a large proportion of grease, called 'yolk', as well as varying proportions of dirt. It is usually exported 'in the grease' and productions are quoted on a 'greasy' basis.[2] The wool may be washed to remove dirt, but if the grease is removed the wool felts or mats together.

1. The introduction of refrigerator ships, by increasing the value of the sheep for meat, and thus concentrating attention on that aspect of sheep farming, led to a change in the character of Australian wool.

2. About four-fifths of the annual import is of 'greasy' wool.

The wool is washed with water containing ammonia or some solvent to remove the grease—a process known as scouring. Greasy wool loses half its weight when scoured. The grease extracted is known as lanoline and is used in the preparation of toilet soaps and cosmetics, and in the pharmaceutical industry. It should be noted that wool taken chemically from pelts is called 'slipes'.

The carding or combing processes result in the separation of 'tops' (the long hairs) and 'noils' (the short hairs), which are combed out.

In general it may be said that the woollen branch uses lower and medium grades of wool, 'noils', mungo (torn rags and tailor's clippings) and shoddy (wool derived from soft woollen rags and knitwear), whilst the worsted branch uses merino and the finer grades of wool.

In addition, other animal fibres are used for certain purposes. Although including some of the finest of textile materials, the rarer animal fibres are usually handled by dealers specialising in 'low wools':

*Mohair* is obtained from the Angora goat and is an important export from Turkey and South Africa. There the goats flourish on the Karroo, where it is too dry for sheep. Mohair makes strong, lustrous materials.

*Cashmere* is the fine, downy winter undercoat of the Kashmir (or Cashmere) goat, a native of Kashmir, Tibet and southern China. Each fleece yields only a hectogram (about 3 oz).

*Camel's hair* is obtained mainly from China and Turkestan. The mane and hump produce strong hair, the remainder of the body downy 'wool'.

*Alpaca, llama, vicuna* and *guanaco* are all animals native to South America, especially on the high Andes of Peru. The wool of the vicuna, a wild animal, is sometimes said to be the finest of all textile materials, and is certainly the most costly.

Owing to the large sheep population of Britain, to the great amount of cross-breeding which has taken place, and to the fact that sheep named after a particular area are rarely confined to that area, it is difficult to generalise about the home clip of wool. Our flocks may be roughly grouped into two classes, however, long-woolled and short-woolled. In the long-woolled class, the best breeds are the Lincoln, which yields a fleece of 4 to 4.5 kilograms (9 to 10 lb) in weight, and the Leicester; whilst other breeds are the Cotswold, the Romney Marsh, and the numerous varieties to be found in Devon and Cornwall (e.g. the South Devon and Devon Longwool), in many of the Midland counties, and in parts of Yorkshire (e.g. the Wensleydale). Most of the long-woolled sheep yield fairly coarse but lustrous wool which is almost invariably combed and spun by the worsted process. The short-woolled sheep fall into two groups, the mountain sheep yielding fleeces weighing about 1.5 to 1.8 kilograms (3 or 4 lb) and the breeds characteristic of the chalk areas yielding 1.8 to 2.25 kilograms (4 or 5 lb) fleeces. The mountain sheep produce very variable fleeces, according to exact breed and region; the roughest wools are used in the

carpet and tweed trades, the fine Cheviot wool for woollens, and the soft short wool of the Welsh and Irish mountain sheep is much in demand for flannels. The Southdown sheep produce the finest type of short wool which, until surpassed by Spanish, later Saxon, and now Australian merino, was the chief source of supply for the fine woollen trade. Now much of the Southdown wool is used either for flannels or is combed for hosiery yarn.

Between one-third and one-half of the home clip is exported—a testimony to its excellent quality—(see table on p. 522) and so extensive imports are necessary to make up the amount required in the wool textile industries.

The following table shows the quantity of wool available for use in the industries in certain years between 1910 and 1960. It should be remembered that the quantity *available* may not be a faithful index of the amount *consumed* in any year, for wool is a non-perishable commodity that can withstand long warehousing.

*Raw material of the wool textile industry* (million lb)

| VARIETY | AVERAGE 1910–14 | AVERAGE 1921–25 | AVERAGE 1926–30 | 1931 | 1935 | 1950 | 1960 |
|---|---|---|---|---|---|---|---|
| Home clip[1] | 95 | 52 | 72 | 86 | 65 | 58 | 78 |
| Imported sheep and lamb's wool, mohair, alpaca, etc.[1] | 506 | 467 | 494 | 601 | 597 | 571 | 355 |
| Wool from imported sheep-skins | 35 | 22 | 24 | 27 | 16 | 37 | * |
| Mungo and shoddy[2] | 206 | 88 | 84 | * | 104 | 71 | 68 |
| Total quantity of wool, mohair, and pulled wool available in United Kingdom | 843 | 630 | 675 | 804 | 782 | 737 | 769 |
| Total (million kg) | 384 | 286 | 306 | 365 | 356 | 334 | 349 |

[1] Balance retained, after deducting exports (or re-exports).
[2] Estimated quantity.
*Not available.
1 lb = 0.454 kg.

Since the Second World War there has been a great increase in the amount of manmade fibres used in the wool textile industries, and in consequence, as with other branches of the textile industry, the nature of the published statistics has changed. The table on p. 506 shows the raw material position in 1968, from which it is apparent that manmade fibres now contribute one-quarter of the total raw materials used.

*Raw material of the wool textile industry, 1968*

| | MILLION LB | MILLION KG |
|---|---|---|
| *Raw wool* | | |
| Merino | 156 | 70.7 |
| Crossbred | 216 | 98.0 |
| Other wools | 20 | 9.0 |
| Total | 392 | 177.7 |
| *Other fibres* | | |
| Hair | 23 | 10.4 |
| Broken tops | 5 | 2.3 |
| Wool noils | 11 | 5.0 |
| Wool waste | 14 | 6.3 |
| Mungo and shoddy | 50 | 22.7 |
| Cotton | 4 | 1.8 |
| Synthetic fibres | 168 | 76.2 |
| Total | 275 | 124.7 |

Finally, the following tables refer to the wool import trade. The greater part of the import of raw wool is of Commonweath origin, Australia and New Zealand being the chief sources. Part of the import from South Africa is mohair.

*Gross imports of wool (including re-exports)* (million lb)

| VARIETY | 1913 | AVERAGE 1921–25 | AVERAGE 1926–30 | 1931 | 1935 | 1955 | 1962 | 1968 |
|---|---|---|---|---|---|---|---|---|
| Sheep and lamb's wool: Merino | | | 359 | 364 | 449 | 388 | 304 | 237 |
| Sheep and lamb's wool: Crossbred | 801 | 819 | 296 | 412 | 332 | 292 | 276 | 252 |
| Sheep and lamb's wool: Other descriptions | | | 146 | 73 | 83 | 42 | 43 | 57 |
| Wool waste and wool noils | 3 | 4 | 4 | 4 | 6 | 11 | 11 | * |
| Mohair | 28 | 22 | 14 | 11 | 11 | 14 | 20 | * |
| Alpaca, vicuna, llama and camel's hair | 13 | 10 | 9 | 8 | 7 | 3 | 4 | * |
| Wool tops | * | 4 | 3 | 2 | 1 | 3 | 3 | * |
| Woollen, worsted, and hair yarn | 33 | 15 | 18 | 19 | 2 | 3 | 7 | * |
| Flocks and shoddy | 122 | * | 51 | 49 | * | * | * | * |

* Not available. Re-exports in 1968 amounted to 13.6 million kg (30 million lb).
million lb = 453 590 kg.

*Imports of wool and mohair by countries* (*less re-exports*) (million lb)

| COUNTRY | 1913 | AVERAGE 1921–25 | AVERAGE 1926–30 | 1931 | 1935 | 1949 | 1955 | 1966 |
|---|---|---|---|---|---|---|---|---|
| New Zealand | 143 | 146 | 117 | 119 | 109 | 162 | 185 | 135 |
| Australia | 126 | 123 | 166 | 218 | 278 | 403 | 337 | 138 |
| South Africa | 81 | 60 | 61 | 69 | 65 | 56 | 64 | 33 |
| Argentina | 52 | 46 | 53 | 90 | 69 | 4 | 32 | 58 |
| Other countries | 104 | 92 | 98 | 105 | 94 | 40 | 118 | 156[1] |
| Total | 506 | 467 | 494 | 601 | 615 | 665 | 736 | 520 |
| Total (million kg) | 230 | 212 | 224 | 273 | 279 | 302 | 334 | 236 |

1 Includes Uruguay 37, China 23.

*Ports importing raw wool* (million lb)

| | 1913 | AVERAGE 1927–30 | 1931 | 1935 | 1948 | 1960 | 1966 |
|---|---|---|---|---|---|---|---|
| Goole | 6 | 10 | 8 | 9 | 9 | – | 19 |
| Grimsby | 15 | 8 | 6 | 4 | — | | 1 |
| Hull | 48 | 136 | 123 | 174 | 60 | 160 | 121 |
| Liverpool | 182 | 143 | 185 | 221 | 282 | 172 | 241 |
| London[1] | 485 | 375 | 391 | 346 | 256 | 162 | 93 |
| Manchester | 0.2 | 14 | 25 | 6 | 14 | 10 | 6 |
| Southampton | 61 | 107 | 107 | 97 | 29 | 25 | 22 |

1 The former dominance of London in this table was a result of the key position held by that city in the world's wool market.
1 million lb = 453 590 kg.

## The chief branches of the woollen and worsted trades

Only the briefest outline of the processes which lie between the raw wool and the finished cloth can be given here, and technical works should be consulted for further details.[1]

1. See, for example, A. F. Barker and others, *Textiles and their Manufacture*, Constable, 1922; or J. A. Hunter, *Wool, from Material to Finished Product*, 4th edn, Pitman, 1930.

The wool is first sorted and classified into grades—long wools (destined for combing and the worsted trade), short wools (for carding, mainly for the woollen trade), and the lowest class for the carpet trade. In this connection it should be remembered that a single fleece is not homogeneous as regards its quality. Different parts of the animal yield wools of varying length and fineness. An allied preliminary process is the sorting of rags and tailors' clippings and their reduction to shreds in tearing machinery. The wool must next be scoured in a soap solution (for which soft water is essential) in order to remove the natural grease which it contains, and machinery must be employed finally to extract all burrs and other foreign bodies which may remain. The dry wool is oiled before passing through the next process in order to render it supple. The short wools are then passed through scribbling and carding machinery, the object of which is to mix up the fibres by taking advantage of their clinging properties and to produce a series of 'rovings' or 'slivers'—thin ropes of roughly parallel fibres—which are subsequently in the spinning process drawn out and given a twist which makes them into thread. During the carding operation any necessary admixtures (i.e. of rag wool, noils, or cotton) may be accomplished. The woollen and worsted branches then follow rather different courses. For worsteds, the finer varieties of carded short wool and also the long wools which have not been carded are put through a combing machine which, by more careful means, so as not to cause damage by breakage and crushing, produces slivers of parallel fibres which are subsequently drawn out into finer and finer threads. The noils (short wools rejected during the combining process) go back into the woollen trade.

Then in both woollen and worsted, the finely drawn-out rovings are spun into a continuous thread. For certain purposes, especially to give strength to the yarn and produce a bi- or multi-coloured yarn, 'doubling' of the thread is performed (i.e. twisting two or more threads into one). All yarns destined to form part of coloured cloths must, of course, have received their dye before being woven. The yarn itself may be dyed, but usually the uncarded wool or the combed tops are dyed before being spun.

Before weaving can begin, the warp and weft threads must be arranged in the required manner. Warping—or building up the warp—is a skilled process, still largely performed by hand; during or after the setting up of the warp, the yarn composing it is treated with size, in order to keep the threads smooth and prevent them from interlocking with one another. The modern high-speed loom is a triumph of automatism, which nothing short of a whole chapter or volume could adequately describe, and the variety of weaves and patterns which can now be mechanically produced is inexhaustible.

The finishing processes are many and varied. The cloth must first be examined for defects and mended where necessary. If woollen, it must be fulled, i.e. shrunk and felted—by being passed through rollers and through soap solutions; the nap must be raised by passing the cloth through drums

set with teazel heads and then cropped by a kind of mowing machine. For worsteds, in which it is desired to show up rather than conceal the pattern of the weave, raising and cropping are unnecessary, but steaming and pressing contribute largely to the great variety of finishes which can be produced. If no colour has as yet been given to the wool the cloth may be dyed in the piece before the final finishing processes are completed.

In recent years the wool-textile industry has been diversified—one might almost say enriched—by the advent of manmade fibres, which have been treated as an ally rather than as a competitor. Many varieties of the new fibres have been successfully blended with wool in varying proportions to give better wearing qualities and new textures. Thus a mixture of 80 per cent wool and 20 per cent nylon is used for carpets; 45 per cent wool and 55 per cent polyester fibre for strong lightweight fabrics; bulk is achieved by mixing stretched and unstretched yarns, for sweaters, and so on. The carpet industry, indeed, has been transformed by the introduction of manmade fibres. In 1968 some 90 per cent of all the carpets produced contained some artificial fibre, and wool represented but 40 per cent of the raw materials used in the industry. In the case of the increasingly popular tufted carpets (only introduced in the middle 1950s and now accounting for nearly half the total output), the contribution of wool is a mere 5 per cent, and the bulk of the raw material is rayon, nylon and acrylic fibres (see Chapter 21). For woven carpets, however (e.g. the traditional Axminster and Wilton types), wool still provides 60 per cent of the total fibre usage.

The following tables present in statistical form the recent history of the wool textile industries. The total employment in the woollen and worsted

*Employment in woollen and worsted industries, by regions*

| | WOOLLEN | | WORSTED | | WOOLLEN AND WORSTED | WOOLLEN AND WORSTED |
|---|---|---|---|---|---|---|
| | 1921 | 1931 | 1921 | 1931 | 1950 | 1966 |
| Great Britain | 139 158 | 98 525 | 120 534 | 103 487 | 218 700 | 158 310 |
| West Riding | 94 578 | 65 406 | 112 376 | 95 550 | 168 130 | 123 680 |
| Lancashire | 8 457 | 6 511 | 320 | 575 | 11 070 | 7 920 |
| Somerset, Wiltshire, and Gloucestershire | 5 726 | 4 686 | 31 | 26 | 5 080 | 3 770 |
| Leicestershire | 486 | 504 | 1 132 | 2 006 | 1 630 | 2 750 |
| Oxfordshire | 1 134 | 1 233 | 19 | 15 | 3 960 | 2 130 |
| Peebles, Roxburgh, and Selkirk | 9 039 | 8 275 | 55 | 58 | 20 870 | 19 130 |

*Note.* 1950 and 1966 figures are for Ministry of Labour Regions—E and W Ridings, Northwestern, Southwestern, Midlands, Southern and Scotland, and are not strictly comparable with previous Census figures. Included in the total are 7900 in other regions (mostly in the Northern Region).

*Employment in woollen and worsted industries, by process, 1953 and 1966* (thousands)

| | 1953 | 1966 |
|---|---|---|
| Combing | 13.4 | 7.9 |
| Worsted spinning | 53.5 | 18.7 |
| Worsted weaving | 32.3 | 18.7 |
| Woollen spinning | 22.4 | 23.4 |
| Woollen weaving | 42.1 | 24.4 |
| Total | 163.7 | 93.1 |

*Source.* Wool Industry Bureau of Statistics. The figures relate to 'productive' personnel only, i.e. excluding administrative, clerical, and transport staff.

branches has declined, particularly during the last decade or so; but this has not meant a decline in the prosperity of Yorkshire or indeed of the other major areas, for the manipulation of manmade fibres has occupied the mills and given alternative employment to the workers. The decline is most noticeable in the worsted branch, for worsted is readily mixed with, or replaced by, manmade fibres, while, to quote the advertising slogan, 'there is no substitute for wool', and employment in wool-spinning has actually increased. The carpet industry has also increased quite substantially, for the use of manmade fibres in carpets has greatly increased the range of products available to an increasingly affluent home market.

*Employment in carpet industry*

| | 1921 | 1931 | 1950 | 1961 | 1966 |
|---|---|---|---|---|---|
| Great Britain | 23 625 | 26 936 | 28 200 | 27 830 | 35 320 |
| Worcestershire | 6 945 | 8 902 | 9 460[1] | 10 800[1] | 12 390[1] |
| West Riding | 6 967 | 5 976 | 6 480[2] | 10 490[2] | 12 710[2] |
| Glasgow | 2 917 | 3 629 | 9 270[3] | 10 000[3] | 11 120[3] |

[1] Midlands. [2] East and West Ridings. [3] Scotland (Ministry of Labour regions).

*Woollen and worsted industries: production, 1907–60* (million lb)

| VARIETY OF PRODUCT | 1907 (UNITED KINGDOM) | 1924 (GREAT BRITAIN) | 1930 (GREAT BRITAIN) | 1950 (UNITED KINGDOM) | 1960 (UNITED KINGDOM) |
|---|---|---|---|---|---|
| Tops | 243 | 286 | 244 | 316 | 319 |
| Noils | 30 | 35 | 28 | * | * |
| Yarns | 446 | 550 | 373 | 656 | 548 |
| Woollen | 260 | 314 | 191 | 329 | 303 |
| Worsted | — | 211 | 158 | 227 | 245 |
| Alpaca and mohair | 186 | 15 | 8 | - | * |
| Other hair or wool | — | 10 | 15 | * | |

* Not avai

*Woollen and worsted industries: production, 1968*

| VARIETY OF PRODUCT | MILLION KG | MILLION LB | MILLION SQ. YD | MILLION SQ. M |
|---|---|---|---|---|
| Tops | 96.5 | 213 | | |
| Yarn, woollen | 230.0 | 325 | | |
| Yarn, worsted | 98.3 | 217 | | |
| Fabrics, woollen | | | 132 | 121 |
| Fabrics, worsted | | | 162 | 148 |
| Blankets | | | 33 | 30 |

# Geographical distribution of the wool-textile industry

## The West Riding

The dominance of the West Riding in all branches of the wool textile industry has been a feature of industrial Britain for over a century. Whereas the worsted branch is almost extinct in those areas of East Anglia and the West Country where it once flourished, the woollen section has maintained a somewhat specialised existence in a number of different regions, notably East Lancashire, the Cotswold country and the Tweed Basin. In 1931 no less than 93 per cent of the worsted workers in Great Britain were in the West Riding, but only 67 per cent of the woollen operatives. The carpet industry has persisted at several localities in Scotland and at Kidderminster–Stourport, and only one-third of the people engaged in the industry are in West Yorkshire.

The two features of principal interest within the West Riding are the geographical distribution of the industries and specialities, and the relation between wool textiles and other occupations. Perhaps the outstanding elements in influencing the area covered by the textile-working district, in Yorkshire as in Lancashire, have been the supply of soft, or lime-free water from the Millstone Grit uplands and the outcrop of productive Coal Measures. The central Pennines, between the South Lancashire and West Yorkshire coalfields, are made up entirely of the Millstone Grit, for the most part peat-covered, and so giving an abundant surface run-off. The Grit consists mainly of hard sandstones, with alternations of coarser and more porous grits, which act as efficient filters and render the spring water extremely pure.

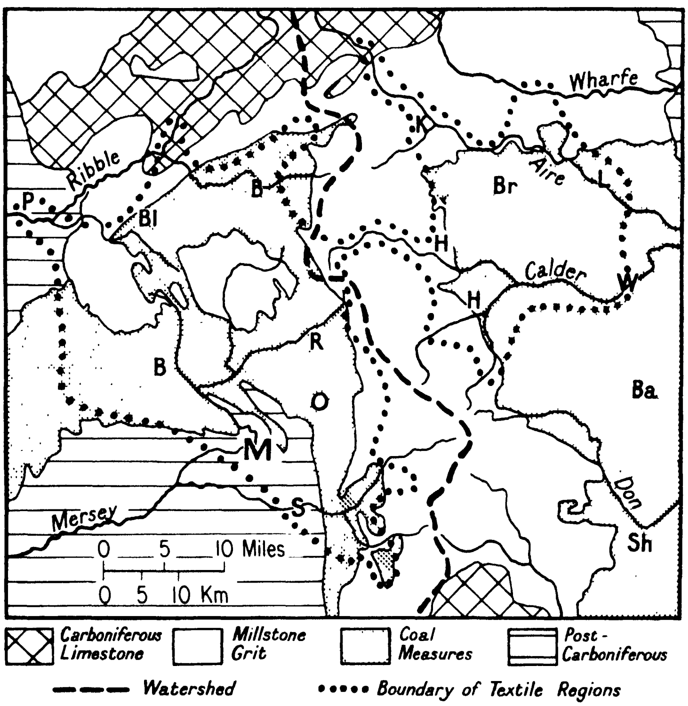



FIG. 187. The textile regions of Lancashire and Yorkshire
Note that the two regions merge across the Roch-Calder watershed.

The West Yorkshire industry is somewhat more localised, however, than the boundaries of the soft-water area would suggest (Fig. 188). Apart from one or two outlying centres on the headwaters of the Dearne and in the Wharfe valley, the industry is confined essentially to the coalfield portions of the Aire and the Colne–Calder valleys, and the area which lies between them, together with the upper portions of those streams on the Grits. Eastwards of Leeds and Wakefield textiles cease to be of any consequence, and

coal mining becomes the chief industrial occupation, but westwards of the main region tongues of industry spread up the Colne valley above Huddersfield, up that of the Calder above Halifax to Hebden Bridge and over into Lancashire, and up the Aire to Keighley and Skipton. The northern boundary of the main region is marked by the edge of the coalfield, roughly coincident with the river Aire. It should be noticed that the Aire, unlike the Colne and Calder, rises in a region of Carboniferous Limestone so that its water is not very soft. As a result, no great centres of the textile trade have grown up on it—the chief towns, Keighley, Bingley, Shipley and Guiseley,

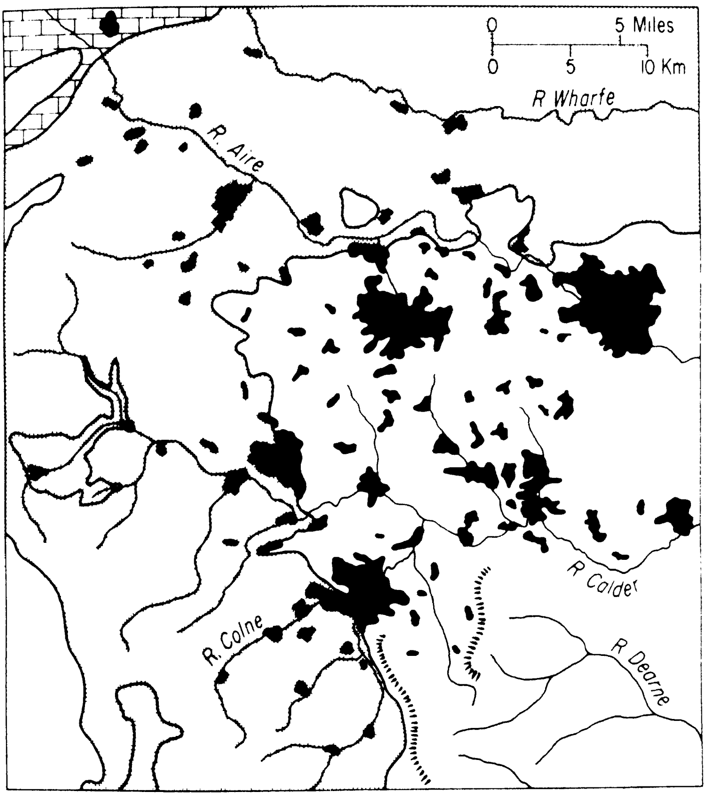



FIG. 188. The woollen towns of Yorkshire in relation to the streams from the Millstone Grit

The Millstone Grit is stippled, Coal Measures left blank. In the southwest are two areas enclosed by lines which are shown on old geological maps as 'Carboniferous Limestone' but are actually of non-calcareous shales now classified with the Millstone Grit. The area in the northwest is of rocks of Carboniferous Limestone age, but is *not* limestone. Notice in the southeast the scarps formed by Sandstones in the Lower and Middle Coal Measures.

being located on small tributary streams rising on the Grits or Coal Measures. The almost sudden cessation of the industry south of the Calder is also remarkable. It is due partly to the paucity of water power in the region of

the Dearne headwaters, which rise on the dipslope of the Coal Measure escarpments, but mainly to the long-standing economic differentiation of the Dearne–Don region, where Middle Coal Measure ironstone was formerly smelted and where textile trades (e.g. linen and coarse woollen cloths called 'pennistones') quite early became subordinate to the coal mining and metal trades of the Sheffield region.[1]

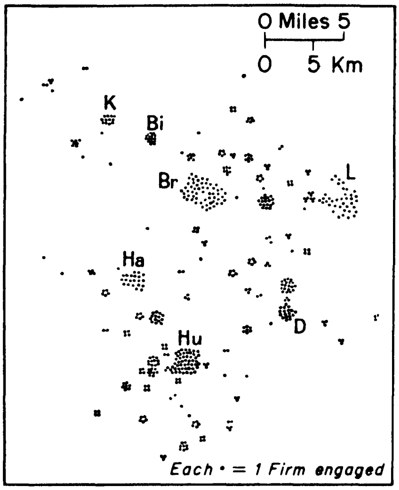



FIG. 189. The woollen industry of West Yorkshire in 1931

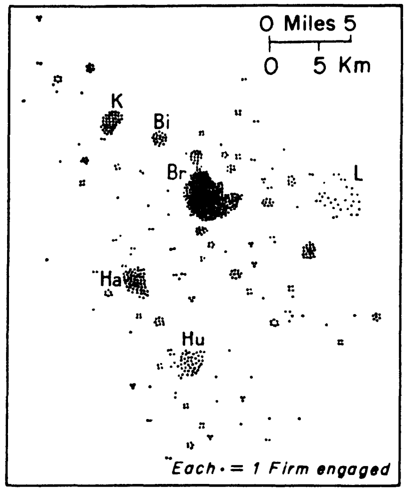



FIG. 190. The worsted industry of West Yorkshire in 1931

Note the general predominance of woollens in the southeast and of worsted in the northwest

K = Keighley; Bi = Bingley; Br = Bradford; L = Leeds, Ha = Halifax, Hu = Huddersfield, D = Dewsbury

For a more recent sketch of the regional specialisms see G. L. Hope, 'The wool textile industry of the West Riding of Yorkshire', *South Hampshire Geographer*, **2**, 1969, 30–7 (map on p. 32)

Within this comparatively restricted area there is a good deal of internal differentiation as regards the particular branches or phases of the wool textile trades which are present. Both woollen and worsted manufactures are to be found all over the area, and there is no sharp regional division between them (Figs 189, 190). Worsted, however, is of relatively small importance in the southeastern part of the area—Wakefield and the Dewsbury region—but is dominant in the northwestern part—Bradford, Halifax and Keighley. The region within a radius of about six miles from Dewsbury, comprising the townships of Dewsbury, Batley, Morley, Ossett, Cleckheaton and Heckmondwike, all north of the Calder, is the greatest in the world for the manufacture of mungo and shoddy and their employment in cloth making.[2] In Dewsbury and Batley there is a large number of firms

1. But see also E. Charlesworth, 'A local example of the factors influencing industrial location', *Geogrl J.*, **91**, 1938, 340–51.
2. See S. Jubb, *History of the Shoddy Trade*, London, 1860, for the early development of this industry.

engaged in the sorting of rags which are subsequently torn up and respun and woven into cloth.

Regional specialisation in certain processes—a characteristic feature of the Lancashire cotton industry—is not much in evidence in West Yorkshire, owing to the peculiar organisation of the woollen branch, in which, as we have seen, a large proportion of the firms engage in all or many of the stages between raw wool and finished cloth. Without attempting to over-generalise, it may be said that in the western portion of the region (Halifax and the upper Calder, Bradford and the upper Aire) spinning and weaving are about equal in the numbers they employ in each centre; in the eastern and southeastern parts, and especially in the small centres south of the Calder, weaving is rather more important than spinning. Dyeing shows a remarkable concentration upon Bradford, attracted thither by the dominance of merchanting and the finishing trades in the city, and is also developed in the middle portion of the Aire valley, between Leeds and Shipley, and in the Calder valley in and around Halifax.[1]

Of individual towns which call for mention, Bradford holds pride of place as the metropolis of worsted and woollen manufacture. This city, apparently in the beginning destined, by reason of its situation on only a tiny stream, to be one of the *less* important centres, has risen since about the 'thirties of last century to a position of prominence unrivalled by its former peers, Leeds and Halifax. In 1800 it had one spinning mill and a population of 13 000. It is probable that the settling within its confines of a number of Jewish merchants, in association with German bankers, soon after 1830, began to increase its importance as a marketing and warehousing centre for worsted goods, and by a process of cumulative growth, and with the aid of the dyeing industry, which was considerably expanded about the same time, it rapidly rose to supremacy. At the present time its activities are concerned principally with combing (i.e. top-making), worsted spinning and weaving and dyeing—but the woollen branch is by no means absent, and Bradford has almost a monopoly in the trades employing alpaca and mohair. Huddersfield concerns itself as much with woollens as with worsteds and is famed for its high-class cloth and its pattern designing. Of the two valleys that converge on Huddersfield, the Holme is devoted mainly to worsted and the Colne to woollens.[2] Halifax, until the rise of Bradford, was the chief worsted centre, and it still deals more in worsted than in woollens.

1. The textile finishing trades employed over 12 000 people in Yorkshire in 1948, about one-half of whom were concerned with wool and worsted and the remainder with cotton mixed fabrics, knitwear, etc. There has since been a steady increase in the importance of mixed fabrics.
2. An interesting account of modern economic reorganisation, involving a reduction in the number of mills (but not in employment), increased horizontal integration in the woollen branch and vertical integration in the worsted branch, as well as the growth of inter-industry groupings involving both branches, will be found in R. C. Riley, 'Locational and structural change in the Huddersfield wool textile industry'. *Tijd. v. Econ. en Soc. Geog.*, **61**, 1970, 77–84.

It is famed for carpets, although numerically the carpet trade gives employment to only three per cent of the town's insured workers. Dewsbury, Batley and the Spen valley towns, as we have seen, form the headquarters of the shoddy trade. Leeds is actually the third town in the conurbation, in respect of absolute numbers employed in the wool textile industry, ranking after Bradford and Huddersfield. But relatively, wool textile manufacture only employs three per cent of the insured workers, and it is the textile-using trades, especially the clothing industry, which are dominant; employment in the latter represents 14 per cent of the city's total (1961).

PLATE 22. Woollen mills in the Holme valley, near Huddersfield
The environment is typical of the early woollen industry, before so much of it became concentrated in the towns.

As regards the relative importance of wool textiles compared with other industries in the West Riding, some interesting unpublished maps made on the basis of the 1921 Census by Dr H. C. K. Henderson[1] showed how, eastwards of a zone running southwards from Leeds *via* Ardsley and Ossett to the headstreams of the Dearne, textiles became subsidiary to coal mining (Fig. 191, and cf. map of Yorkshire coalfield, p. 308). Few mines remain within the textile region, which has thus to a certain extent lost one of the bases upon which its industry was built.

Fig. 192 shows the relative importance of wool textile industries in the various West Yorkshire centres, thirty years later. In every town the wool

1. Shown to the British Association (Section E) at York, 1932.

textile trades are less important relatively, and frequently absolutely also, than they were in the 1920s. This is partly due to increasing mechanisation and the consequent displacement of many employees, and partly to the great increase in the employment capacity of other industries, e.g. engineering, electrical trades and numerous 'consumer goods' industries, particularly in the larger towns. It is only in a few of the smaller peripheral centres (e.g. Slaithwaite, Haworth, Holmfirth) that wool textiles now employ more than 40 per cent of the insured population.

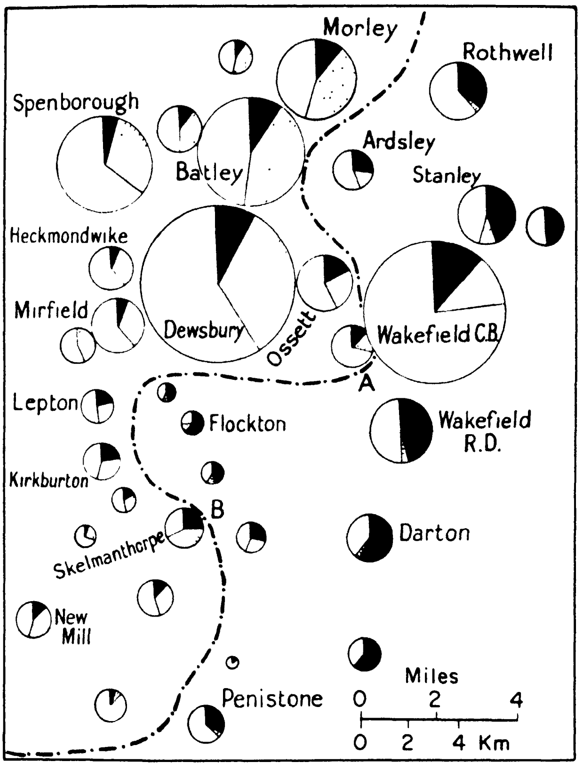



FIG. 191. The transition between textiles and coal mining occupations by census divisions

Circles proportional to the number of people employed in 1921
Black = coal mining, dotted = textiles, blank = all other occupations. West of the broken line, textiles more important than mining east of the same, mining more important than textiles. This line of division between A and B coincides with the Calder Dearne water parting (compare Fig. 188).
(Map prepared by H. C. K. Henderson.)
It is not yet possible to compile this map afresh on the basis of the 1961 Census. But coal mining is now almost extinct within the wool textile region.

In the textile zone as a whole, in 1964, 180 000 people found employment in the textile industries—21 per cent of all employment; and there were 47 000 others employed in the clothing trades (including footwear).

Of the major urban centres, Leeds is the most diversified city in the whole conurbation, and several occupations exceed wool textiles in importance, such as tailoring (cf. p. 613), engineering (pp. 438, 450), transport services, distributive trades and professional services. Bradford has a considerable dyeing and finishing industry, together with electrical and general engineering and the making of textile machinery and motor vehicles. Halifax and Huddersfield each make clothing and have textile machinery and other

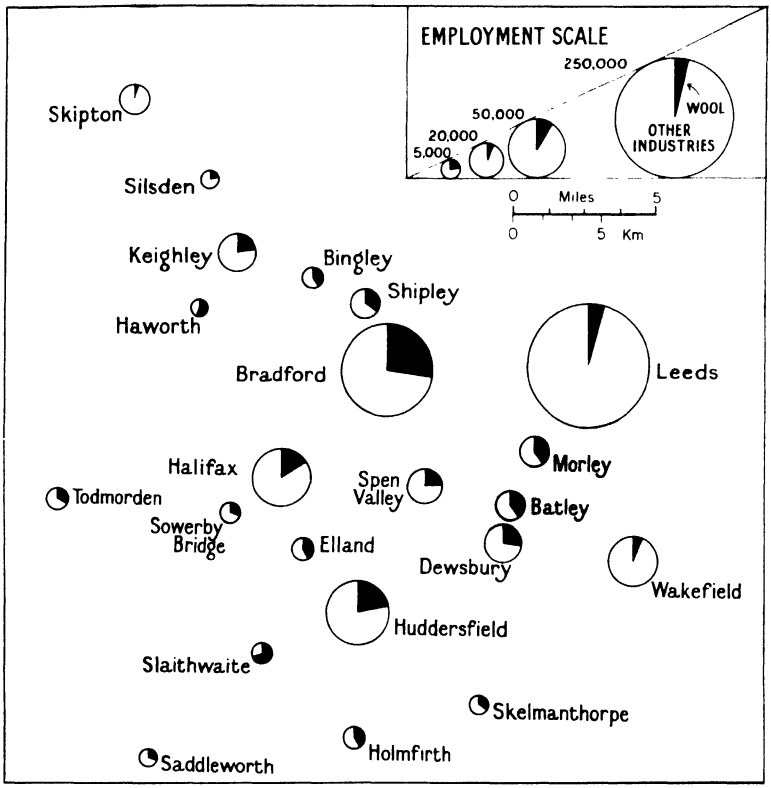



FIG. 192. Map showing the relative importance of the wool-working industries in the industrial economy of the West Yorkshire towns—Census of 1951

engineering industries, whilst Halifax has also the carpet trade and brass and wire industries, and Huddersfield a considerable dyestuffs industry and vehicle building. In Wakefield only 10 per cent of the total employment is in textiles. Dewsbury and the Spen Valley towns still have about one-quarter of their people employed in wool, and there are important textile machinery and other engineering industries. Keighley has textile machinery works (cf. Fig. 179), whilst in the western fringes of the wool-working district we find Skipton using cotton and manmade fibres, Hebden

Bridge with large clothing and cotton manufactures, and Sowerby Bridge with a subsidiary cotton industry.

### East Lancashire

The ancient woollen industry of South Lancashire has become very restricted and specialised since the growth of cotton manufacturing. As stated above (p. 498), it has been pushed eastwards up the Pennine valleys, where there are now two areas concerned, one north of Manchester, in the valley of the Roch where Rochdale and Bury are the chief centres, and the other east of Manchester, in the Tame valley about Mossley and Stalybridge. The woollen branch predominates, notably felts (upon which an extensive slipper industry depends), flannels and blankets.

### West of England

The decline and increasing specialisation of this region have already been considered (p. 501). The spinning of yarn has practically ceased and the weaving and finishing of special types of cloth is all that remains. Stroud is still the principal centre of the trade in highly finished cloths of the broadcloth type for liveries, uniforms, hunting outfits and billiard tables. Outlying centres continue to flourish in a small way, such as Dursley, making woollens and carpets, Witney,[1] the blanket town, Trowbridge, woollens and some worsted, Frome, Wellington and one or two minor survivals of the Devonshire serge trade, as at Ashburton. The carpet industry continues to flourish at Wilton (Wiltshire) and Axminster (Devon) which, like Kidderminster in the Midlands, have given their names to types of carpet not necessarily manufactured at the centres concerned.

### Wales

Many parts of Wales formerly had a considerable domestic woollen industry, using locally produced wool. Much of this industry has been mechanised and factories, most of them small, are to be found scattered in a great many towns and villages in central and west Wales. The greatest concentration is in Carmarthenshire in the valley of the Teifi between Lampeter and Newcastle Emlyn. Flannel and 'Welsh blankets' are the principal products.

### Leicestershire

The growth of the woollen and worsted industries is a natural outcome of the expansion of the hosiery trade. As a result, they are of rather a specialised nature, being concerned primarily with the production of worsted and

1. One firm at Witney claims to have been making blankets since 1670. See A. Plummer, *The Witney Blanket Industry*, Routledge, 1934.

some woollen yarn destined for subsequent manufacture, within the same region, into hosiery proper and all allied types of 'knitwear'—underwear, pullovers, bathing costumes, etc. The principal seat of the industry is Leicester, but a number of neighbouring towns share it to a certain extent, as Melton Mowbray, Wigston and Loughborough (cf. Chapter 21).

## The Scottish Border

A well established domestic linen and woollen industry existed in the Tweed basin prior to the Industrial Revolution, based upon local flax-growing and wool from the Cheviot and Blackfaced mountain sheep, and aided by copious supplies of soft water from the limestone-free Silurian and Old Red Sandstone formations. The decline of the linen trade due to competition from better situated areas in Fifeshire and Ireland, and the introduction of machinery into woollen manufacture, brought about a changed distribution. Attention became focused on water-power sites on the change of gradient between the narrow tributary valleys and the broader central basin of the Tweed—and towns situated in such places as, for example, Galashiels and Hawick, expanded considerably as a result. Subsequent development was hampered, however, by the absence of coal, the somewhat isolated nature of the region as regards populous markets, and the attendant lack of facilities for easy import of foreign wool. Competition with Yorkshire being out of the question, specialisation has occurred and the region has become world famous for 'tweeds'[1] of high quality, and for hosiery of all kinds, the latter being the speciality of Hawick. In consequence much foreign wool is now imported, and the industry survives today by reason of a foundation laid during a period when local geographical conditions were more favourable. The site conditions, owing to the narrowness of the valleys, are not very favourable for mill and town development, and in the 'seventies of last century the Galashiels industry had to find a new outlet at Selkirk, with the result that the population of the county named after that town increased by 80 per cent between 1871 and 1881.

The depression which followed the First World War, with its accompanying lack of real demand for the costly high-quality products, hit the industry badly. A partial relief was obtained by the introduction, as at Jedburgh, of the artificial silk trade; but the present adverse geographical and economic factors are outweighing even the momentum of several centuries.

## The rest of Scotland

Just as in Wales, the natural aptitude of many parts of Scotland for sheep rearing, together with the abundance of soft water, gave rise to a wide-

1. The name was originally 'twill' or 'tweel', which an English clerk's error transformed into tweed—and this misspelling happening to be the name of the river basin, it has stuck to the cloth and the trade.

spread domestic woollen industry, of which, despite the progress of mechanisation and the development of factories, many scattered remnants still remain. Small mills for spinning and weaving tweed and other cloths, blankets and carpets are to be found in nearly every county. and only one or two of the more important regions can here be mentioned. Although completely overshadowed by more modern industries, the old woollen trade survives in Ayrshire, as at Kilmarnock and Ayr, and in the Glasgow–Paisley district, where carpets and blankets are made and where the industry is partly an associate of the cotton industry. Between the Forth and the Tay, on the steep southern slope of the Ochil Hills, where there was abundant water power, the woollen industry still remains centred on Alva, Alloa and Tillicoultry; and numerous small mills are to be found in the valleys running southeastwards and northeastwards from the Grampian massif. Finally, mention must be made of the hand-loom production, in the Hebrides, of the famous 'Harris homespun' tweeds; and of the domestic hosiery industry of the Shetlands. These trades are now much more commercialised than formerly, and machine-spun yarn is used in order to speed up production.[1] The chief spinning centre in the Highlands is Brora, on the small coalfield.

**Ireland**[2]

Here, as before, we find a scattered domestic woollen industry which has become partly industrialised. A number of towns in Northern Ireland, and some in Eire, notably in the hinterland of Cork, have mills where woollen cloths, tweeds and blankets are produced, but Belfast, Ballymena, Newtownards, Dublin and Cork are the only towns where more than one firm is engaged.

## Export trade

The following tables show the fortunes of the export trade in wool and manufactures thereof since 1913. It is interesting to note that the export of British raw wool is still a flourishing business. For the rest, it is clear that semifinished material, in the shape of tops and yarn, is very important—serving the developing woollen and worsted industries of other countries; the export of cloth has declined somewhat from the figures of a few decades

1. The term 'Harris Tweed' is restricted to cloth produced from Scottish wool spun in the Island and woven in the houses of the people. There are several carding and spinning mills, mostly at Stornoway, but there are some 800 members of the Harris Tweed Association; they produce 2.7 to 3.6 million metres (3 to 4 million yards) of cloth a year, all of it of high quality and much of it destined for export. The industry is the mainstay of the economic life of many of the Islanders. See H. A. Moisley, 'Harris Tweed: a growing Highland industry', *Econ. Geog.*, **37**, 1961, 353–70.
2. D. J. Dwyer and L. J. Symons: 'The development and location of the textile industries in the Irish Republic', *Irish Geog.*, **4**, 1963, 415–31.

*Exports of wool and woollen goods by variety* (in 100 centals = 10 000 lb = 4535.9 kilograms)

| VARIETY | 1913 | AVERAGE 1921–25 | AVERAGE 1926–30 | 1931 | 1935 | 1950 | 1966 |
|---|---|---|---|---|---|---|---|
| Wool (British only) | 2 866 | 5 209 | 4 118 | 3 577 | * | 2 536 | 4 387 |
| Noils and waste | 3 388 | 3 449 | 3 166 | 2 011 | 3 580 | 4 938 | 3 849 |
| Tops | 4 363 | 3 736 | 3 431 | 2 799 | 5 593 | 7 289 | 21 301 |
| Yarn, worsted | 4 990 | 3 712 | 3 786 | 2 978 | 3 308 | 2 396 | 1 230 |
| Yarn, woollen | 481 | 784 | 654 | 515 | 781 | 605 | 1 593 |
| Tissues, worsted (million sq. yd) | 62 | 54 | 41 | 30 | 38 | 40 | 24 |
| Tissues, woollen (million sq. yd) | 106 | 129 | 113 | 56 | 71 | 84 | 54 |
| Yarn, alpaca, and mohair | 1 722 | 738 | 761 | 406 | 438 | 220 | 337 |
| Other yarns of hair and wool | 848 | 307 | 712 | 640 | * | 300 | |
| Flocks, shoddy, and rags | 2 326 | 2 501 | 3 106 | 2 269 | * | 4 350 | * |
| Piece goods (million sq. yd) | 187 | 185 | 169 | 95 | * | * | * |
| Carpets (million sq. yd) | 11 | 7 | 7 | 3 | 6 | 12 | 15 |
| Blankets (1000 pairs) | 1 002 | 1 235 | 990 | 409 | 417 | 1 360 | * |
| Flannels (million sq. yd) | — | 6 | 4 | 3 | 5 | * | * |

* Not available.

*Exports of wool and woollen goods by countries* (£ millions)

| COUNTRY | 1913 | AVERAGE 1921–25 | AVERAGE 1926–30 | 1931 | 1935 | 1955 | 1966 |
|---|---|---|---|---|---|---|---|
| Germany | 9.5 | 7.0 | 8.7 | 4.0 | 2.4 | 14.0 | 18.4 |
| Canada | 4.4 | 6.2 | 6.6 | 2.6 | 3.4 | 17.2 | 15.9 |
| Australia | 2.4 | 5.3 | 3.1 | 0.3 | 1.1 | 2.0 | 4.2 |
| New Zealand | 0.5 | 1.2 | 1.3 | 0.6 | 0.8 | 5.0 | 3.4 |
| South Africa | 1.5 | 1.5 | 1.6 | 1.2 | 1.9 | 7.0 | 5.0 |
| China | 0.6 | 3.7 | 3.2 | 1.8 | 0.6 | 5.2 | 0.3 |
| Japan | 1.9 | 7.3 | 2.8 | 1.2 | 0.7 | 4.7 | 10.2 |
| India | 1.3 | 1.0 | 1.3 | 0.4 | 0.7 | 6.7 | — |
| Other Countries | 11.9 | 27.4 | 22.4 | 13.1 | 18.8 | 91.6 | 59.4 |
| Total | 34.0 | 60.6 | 51.0 | 25.2 | 30.4 | 153.4 | 117.0 |

Other countries in 1966 included USA (£20.8m), Denmark (£11.4m) and Hong Kong (£6.8m).
These and similar tables may be kept up to date from the annual *Accounts relating to Trade and Navigation of the United Kingdom*, HMSO.

ago, but it is maintained on the basis of quality—for Yorkshire cloth (like Wedgwood china) still commands a substantial market in North America and the 'white' Commonwealth countries. Liverpool, by reason of its proximity to Yorkshire and its regular worldwide shipping connections, continues to dominate the export trade.

*Ports exporting wool and woollen manufactures* (millions of £s sterling)

| | 1913 | AVERAGE 1927–30 | 1931 | 1935 | 1948 | 1960 | 1967 |
|---|---|---|---|---|---|---|---|
| Goole | 2.9 | 4.9 | 2.7 | 3.5 | 4.7 | — | 1.1 |
| Grimsby | 5.8 | 3.3 | 1.4 | 0.9 | 0.2 | — | 0.5 |
| Hull | 5.7 | 11.5 | 4.4 | 8.5 | 9.2 | 23.0 | 7.4 |
| Liverpool | 11.7 | 21.1 | 8.0 | 10.2 | 41.7 | 37.3 | 14.5 |
| London | 6.6 | 10.2 | 5.2 | 7.0 | 15.3 | 8.8 | 9.0 |
| Manchester | 0.7 | 1.8 | 0.6 | 1.1 | 10.5 | 12.2 | 4.1 |
| Southampton | 1.2 | 3.0 | 1.6 | 2.1 | 7.8 | 6.3 | 2.5 |
| Glasgow | 0.5 | 1.6 | 0.6 | 0.9 | 4.0 | 1.9 | 1.9 |

# 20 The textile industries: cotton

The cotton industry, unlike that of wool, has no long history stretching back into the Middle Ages; its development and expansion were roughly coincident with the period of the Industrial Revolution. Moreover, it has always been entirely dependent upon imported raw material and during its periods of greatest prosperity was very largely dependent upon foreign outlets for its produce. Since the Second World War, the picture of the cotton industry has been metamorphosed completely, with both yarn and cloth now figuring highly among the imports and the present quantity of exports reflecting only a shadow of the former valuable export trade. That section of the textile industry which is still mainly dependent on cotton now represents only one-sixth of the whole, and indeed it has been asserted with some truth that 'the cotton industry', as we knew it before 1940, no longer exists. Nevertheless, an industry which employed 624 000 people in 1913 is worthy of close consideration, especially since 96 per cent of those employed at that date were to be found in one area, southern Lancashire and the adjacent parts of Cheshire and Derbyshire. Such a remarkable concentration cannot be explained by the simple factors of power supplies and transport facilities alone, the prime necessities of an industry relying on considerable overseas trade. Several other regions of Britain possessed equally good advantages in this respect. Therefore, it will be our business in this chapter to attempt an analysis (*a*) of the factors which contributed to the original localisation of the cotton industry in Lancashire and elsewhere, (*b*) of the physical and economic circumstances which enabled the Lancashire region to adapt itself to new discoveries and new requirements and so to develop the remarkable concentration and specialisation which characterised it during the peak years, and (*c*) of the technological, economic and political influences which have accelerated the decline of the cotton industry since the Second World War.

## Historical geography of the cotton industry[1]

### 1600–1770

It is probable that, from the thirteenth century onwards, small quantities of cotton wool were imported into England for the making of candle wicks,

and in the sixteenth century this trade was fairly regular. Definite evidence of the spinning and weaving of cotton in this country is lacking, however, until about 1600. Cotton had been utilised on the Continent for a considerable period (in Spain, Italy, Germany and Belgium, for example) and it is probable that Flemish refugees introduced it into Britain. At Norwich, the home of fine fabrics (cf. p. 497), fustians and bombazines (mixtures of linen and cotton, or silk and cotton) were being made, possibly before 1600 and certainly in 1605, and in south Lancashire, where many foreigners settled, fustians began to be produced about the same time, using cotton imported from Smyrna, the Levant and Cyprus, and linen from Scotland and Ireland. In East Anglia the manufacture was clearly an ally of the worsted industry which we have already discussed (Chapter 19). In south Lancashire it attached itself quite naturally to an existing linen and woollen industry. Manchester was making woollen cloth in the early fourteenth century, and in the sixteenth century the linen trade of Manchester, and the 'Manchester cottons' (made of wool) produced at that town and at Bolton are commented upon by Leland. The use of cotton was slow in developing, however, and as yet the fibre was only used for mixing with others, for it could not be spun into a thread strong enough for employment as warp. By the end of the seventeenth century, aided by the great damage done to the continental industry by the Thirty Years War, and by the increasing demand for fustians, the industry was definitely established and concentrated chiefly in the Manchester region.

Manchester, like Birmingham (cf. Chapter 18, p. 466), was a non-corporate town—'neither walled town, city, or corporation' (Defoe)—free from the strict regulations of the larger populous centres and thus able to accommodate foreigners and new industries without trouble. It lay, too, outside the area dominated by the trading activities of the Merchant Adventurers, and so could develop unhampered by restrictions. Three branches of the textile industry grew up—the woollen 'cottons' referred to above, checks and small-ware (tapes, etc., often made of worsted), and fustians (made from linen warp and cotton weft). At the same time, whilst Manchester was the centre of the new industries, Bolton also made fustians, Rochdale and East Lancashire generally still retained a flourishing woollen trade, and Warrington, developing as a port, was famed for its sail cloths. The prohibition (at the instigation of the silk and woollen manufacturers) of the import of printed and dyed calicoes obtained from India, in 1700, resulted in the setting up of a printing and dyeing industry in London (where the 'grey' cloths were imported) and in Lancashire; and when in

1 (page 525). Of the abundant literature on the history of the cotton industry, the following books are 'classics': E. Baines, *History of the Cotton Manufacture*, 1835; S. J. Chapman, *The Lancashire Cotton Industry*, 1904; G. W. Daniels, *The Early English Cotton Industry*, 1920; Wadsworth and Mann, *The Cotton Trade and Industrial Lancashire, 1600–1780*, 1931. A more popular account will be found in Wood and Wilmore, *The Romance of the Cotton Industry in England*, 1927.

1721 the *use* of printed calicoes was forbidden, Lancashire took up fustian-printing, an industry which was legalised by the famous 'Manchester Act' of 1736.

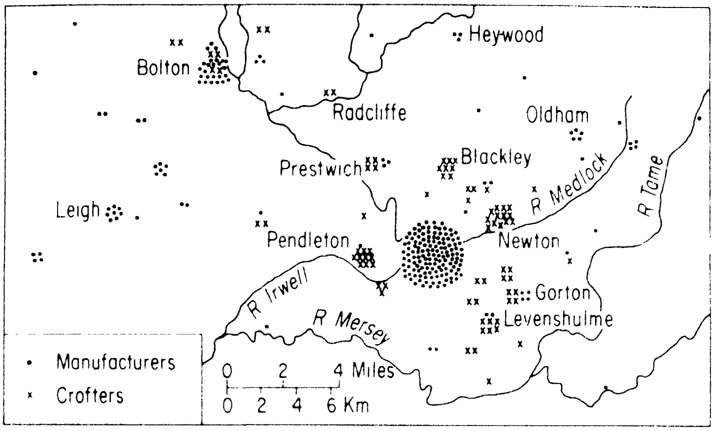



FIG. 193. The distribution of cotton users in south Lancashire at the end of the pre-machinery period

The large cluster of dots represents the manufacturers of Manchester

The steady, if slow, expansion of the cotton-using industries in Lancashire during the first half of the eighteenth century[1] was accompanied by the rise of Liverpool as a port. With the gradual silting up of the Dee estuary, Chester was declining,[2] and the improvement of Warrington in the 1690s, followed by the construction of the first docks at Liverpool in 1715, and the improvement of the Mersey-Irwell navigation to Manchester, commenced in 1720, are evidence of the need for oceanic inlets and outlets for the growing trade of south Lancashire. Liverpool was not really important as an importer of raw cotton, however, until the main source of supply shifted from the east to the west (i.e. the United States). The one great handicap of the Manchester region (cf. Birmingham) was the lack of good roads. The pack-horse provided the only available means of overland transport and most of the raw cotton was obtained from London by this method. Another feature which prevented much expansion until after the invention

1. In 1701, just under 900 000 kilograms (2 million lb) of raw cotton were imported; in 1751, nearly 1.3 million kilograms (3 million lb).
2. See H. W. Ogden, 'Geographical basis of the Lancashire cotton industry', *J. Textile Inst.*, **18**, Nov., 1957, T573–594 (useful maps).

of machinery was the scattered and rather widespread nature of the domestic spinning and weaving industries, which at this time were largely part-time occupations of families also engaged in farming. Although from quite early times the merchants (the equivalent of the Yorkshire 'clothiers') employed large numbers of people, large-scale output of homogeneous fabrics was obviously impossible before the coming of the factory age.

Fig. 193 shows the distribution of the cotton-using industries in south Lancashire at the end of the pre-machinery period.[1] The concentration on the Manchester district is remarkable, and may be regarded as an expression of the dominance of that town over the Lancashire region. Defoe had described it as 'the greatest mere village in England', with a population, in its parish, of some 50 000; and whilst there was as yet no incentive to move into the comparatively barren hill country in search of water power, the lowland agricultural area around the Medlock and middle Irwell basins proved the more attractive region. Of the 'manufacturers' shown in Fig. 193, the makers of small-ware were all in Manchester; the checkweavers mostly in Manchester and an 'inner circle', comprising what are now the city's suburbs (e.g. Failsworth, Gorton, Levenshulme) and the fustian makers in Manchester, and in an outer semicircle on the edge of the uplands (e.g. Leigh, Bolton, Oldham). The crofters or 'whitsters' who performed the bleaching operations[2] were grouped in the villages around Manchester (Blackley, Newton, Pendleton) and in the Irwell valley (e.g. Prestwich, Radcliffe, Bolton)—a location which, as we shall see, has been preserved even to the present time, though the methods and requirements have changed considerably.

## The Industrial Revolution

The factors which contributed to the localisation of the cotton industry in South Lancashire in the seventeenth century—the existence of linen and woollen industries in the soft-water region of the Pennine flanks, and the settling of foreigners in a non-corporate town are not sufficiently exclusive or conclusive to explain the later concentration. Numerous other regions had soft water, Flemish weavers, and an atmosphere humid enough for successful spinning. The secret of the expansion of the industry in Lancashire lies in the fact that as each new development arose, so the natural environment of the region was found capable of being utilised in the desired manner. When machinery was invented, water power was available; when steam power arrived coal could not have been in closer proximity; the development of chemical bleaching was aided by the presence of the Cheshire saltfield, only a few miles away, and by the abundance of soft water; and the need for transport could be satisfied by comparatively easy canal and

1. Data from Daniels, *op. cit.*, pp. 69–70.
2. The method employed was to steep the cloth in sour milk, spread it out on grassy slopes, and allow the sunlight to do the bleaching. It was a process occupying several months.

railway construction, and by the enlargement of the existing ports of Liverpool and Manchester. The Industrial Revolution period witnessed all these factors in operation.

Before the invention of machinery the textile industries were essentially home occupations. The homemade spinning wheel and hand loom were the only essential requirements. The difficulty which weavers experienced in getting adequate supplies of yarn[1] was only aggravated by Kay's flying shuttle (patented in 1733, but not much used until the 1760s), and in consequence the early inventions were all designed to facilitate the spinning process. Hargreaves's 'jenny' (origin of the name is obscure) merely multiplied the number of spindles which could be handled by one operative,[2] and still could not produce a yarn strong enough for warp. Arkwright's invention[3] of roller spinning, however, making use of rollers moving at different speeds for drawing out the rovings into yarn, remedied this deficiency. His machine, although patented at first to be worked by a horse, was quickly adapted for driving by water power, and hence came to be known as the 'water frame'. It may be said to have wrought two great changes in the cotton industry. In the first place, it made possible the weaving of all-cotton cloth (calico)—a manufacture which, owing to the existing prohibitions (see above), had to be legalised in 1774—and thus, by rendering unnecessary the admixture of linen and wool, contributed to the decline of those industries in Lancashire;[4] secondly, it caused the first vital change in the localisation, within Lancashire, of the production of yarn, by making water power an essential. But progress in the use of water power was at first slow. There was a natural reluctance on the part of the people to work in factories; then the lapse of Hargreaves's patent allowed the rapid spread of the jenny, which needed no power, and Arkwright, driven from Lancashire by hostility to his machines,[5] set up his works in Nottingham, the home of flourishing hosiery, lace and silk industries, and later at certain water power sites in the hosiery-making district of Derbyshire (Cromford 1771, Derby 1773, Belper 1776). Another factor contributing to the expansion of the industry was Crompton's mule, constructed in 1779 and so called be-

1. 'It was no uncommon thing for a weaver to walk three or four miles in the morning and call on five or six spinners before he could collect enough weft to serve him for the remainder of the day' (Guest, *Compendious History of the Cotton Manufacture*, p. 12). The situation was aggravated in the summer months by the spinners neglecting their spindles for more urgent agricultural labour.

2. The first jenny, in 1770, had sixteen spindles. Twenty years later machines were being constructed with over 100.

3. Like so many 'inventions', the principle of roller spinning was not the product of the brain of the man whose name is associated with it. It is due to Lewis Paul, whose first machine was made in 1738—thirty years before Arkwright's patent.

4. By 1790 woollen manufacture had disappeared, except in a specialised form in East Lancashire, and the linen industry was almost dead.

5. Arkwright did not at first intend to make calico, but as the Lancashire weavers refused to buy his machinemade yarn he had to use it himself in the manufacture of all-cotton cloth.

cause it combined the principles of the jenny and the roller. This machine spun thread for both warp and weft, and was capable of producing counts of much greater fineness than ever heretofore. As it was never patented, its use quickly spread, and in the 'eighties it began to supersede the jenny. It was not adapted for water power until 1790, after which, during the last decade of the century, it was adopted for producing the finer types of yarn, Arkwright's water frame spinning the coarser counts.

The early machinery age thus falls naturally into two periods. The first, from 1770–90, is characterised by the endeavour to provide an adequate supply of yarn, by the birth of the new cotton industry, by the inauguration of the factory system, consequent upon the use of water-driven machinery, and by an important migration of the industry away from Manchester and into the steeply graded valleys of the western Pennines and the Rossendale upland, where water power was available. The second, from 1790 until 1800, is a period of development and consolidation, in which two pieces of machinery played important parts. The mule enabled the trade in fine fabrics, for so long an Indian monopoly, to be captured by Lancashire and by the Glasgow–Paisley district of Scotland, where the cotton industry began to supersede that of linen (see p. 563). The steam engine, which Watt began to develop for driving machinery about 1782,[1] not only enabled far greater power to be obtained, but also confirmed the existing localisation of the industry on the Lancashire and Lanarkshire coalfields. The increasing use of machinery gave rise to a new industry—the building of machines for the mills which were springing up in many of the coalfield valleys. The import of cotton rose by leaps and bounds, a new and prolific source of supply appearing in the United States.[2]

All this time, however, weaving had lagged seriously behind spinning in technical developments, with the result that the hand-loom weavers, supplied now with a surfeit of machine-spun yarn, were enjoying a period of great prosperity. It is true that Cartwright had invented a power loom in 1785, but although several were erected none was successful until, about 1804, Radcliffe overcame the liability of the cotton yarn to break when subjected to mechanical handling by steeping the warp in boiling size before mounting it in the loom. Thus it was not until about 1806 that the power loom, later improved by Horrocks, became a commercial proposition—to the serious detriment of the hand-loom weavers.

Two trends are to be discerned in the localisation of the weaving industry. At first, there was a temporary migration of many of the cottage looms into weaving sheds attached to the new beckside spinning mills. Then, with the introduction of the power loom, a process of disruption began, due to a

1. The first engine for a cotton mill was erected at Papplewick, Notts., in 1785; Manchester obtained its first in 1789, and Glasgow in 1792. By 1800 Manchester had thirty-two engines.
2. Import of raw cotton in 1781—2.2 million kilograms (5 million lb); 1800 25.4 million kilograms (56 million lb). See also p. 535.

number of causes. The hand-loom weavers were a body of skilled workers who objected to working in 'factories', and who saw in the coming of machinery the grim spectre of unemployment and ruin. Unlike the early spinning machines, the power looms did not need skilled operatives and could be worked or attended by women and children—at, of course, low wage rates. It is little wonder then that many of the early machines and factories were damaged or destroyed in a series of riots during the second and third decades of the nineteenth century.[1] Many weaving masters, potential factory builders, migrated to the northern slopes of the Rossendale upland, where the cotton industry was less highly developed and where the hatred of machinery was less intense. To this migration, and to the increasing separation of spinning and weaving, due to the large number of new fabrics and the impossibility of weaving firms spinning all the varieties of yarn which they required, the beginnings of the modern specialisation in the industry, dating from about 1840, are due.[2] The use of the power loom did not take the industry by storm, however, as the spinning machines had done,[3] and for a long period, just as in the woollen industries, the hand loom continued to be an important factor in cotton manufacture. Even in the 1830s, when the cotton industry in Great Britain possessed about 100 000 power looms, perhaps 250 000 hand-loom weavers remained.[4] Some remained in Glasgow for example—even after 1880.

It must not be assumed that spinning and weaving were the only two processes in the cotton industry to be mechanically performed. As far back as 1748 Lewis Paul had patented a carding engine, and Arkwright placed a whole series of carding and drawing machines on the market in the late 'seventies. Many other machines were designed to perform the many processes through which the raw cotton goes before it is ready for spinning.

Another very important series of inventions concerned the bleaching and dyeing of yarn and cloth and the printing of calico. The year 1785 witnessed great advances in the methods of both bleaching and printing. Berthollet, a French chemist, discovered the bleaching properties of chlorine and his ideas quickly became known in Lancashire, the centre of the English calico industry. The new process, as improved by Henry and others in Lancashire, reduced the time necessary from many months to a few days. Its essential requirements were chlorine, easily obtained by canal from the salt deposits of Cheshire; lime, sent by canal from the Carboniferous Limestone region

1. We must not assume that the Luddite and other riots were due *entirely* to the fear of machinery. The general resentment of wage levels and food prices during the great depression which followed the Napoleonic wars should also be taken into consideration (Daniels, *op cit.*, pp. 83–91).

2. See J. Jewkes, 'The localisation of the cotton industry', *Econ. Hist.*, 2, Jan. 1930, 91–106.

3. Domestic spinning was almost extinct in the towns by 1785, although it lingered in the country districts for several decades. In 1813 there were about 100 power looms in the Manchester district, and about 2400 hand looms.

4. This figure, given by Baines (*op. cit.*, p. 396), is generally regarded as being too high.

of Derbyshire,[1] and sulphur, which began to be obtained from pyrites imported from Spain *viá* Liverpool. The assembly of these raw materials by canal and sea resulted naturally in the foundation of a chemical industry at the head of the Mersey estuary, whilst the bleaching industry suffered no change in its location. The bleaching works of the pre-machinery period were fortunately (for boiling water of lime-free character is the chief item in the process) situated on the coalfield and well within the soft-water area of the southern flank of the Rossendale upland, and were also near to Manchester, the finishing and marketing centre.

In 1785 also, cylinder printing was invented. Replacing the old woodblock and copper-plate methods, which had been in use in Lancashire for twenty years, this piece of machinery, later assisted by the transfer process of engraving, could perform the work of 100 men, and so greatly speeded up the printing of calico, reduced costs and enabled a vastly greater output to be obtained.

The development of the cotton industry was facilitated during the Industrial Revolution period by the growth of transport facilities, especially in the form of canals (cf. Chapter 26). Although the earliest canals (Sankey Canal, 1760; Bridgewater Canal, 1761) were designed to provide outlets for the coalfield, the rapid development of the cotton industry after 1770 was followed by a period of intensive canal construction. The Leeds and Liverpool Canal provided an outlet for the northern area (Blackburn–Burnley) as well as for the wool textile region of the West Riding; the Rochdale Canal served Rochdale and the southwest of the Yorkshire woollen region; the Manchester, Bolton and Bury Canal served the Irwell valley; and the Huddersfield Canal linked the Ashton–Stalybridge area with Manchester. Many new mills grew up alongside these canals.

The essential features of the Lancashire cotton industry were thus outlined during the Industrial Revolution period, and just as in the wool textile industry the localisation has changed little since that time, although the relative importance of the various centres may have been somewhat modified. Thus in 1838 Manchester still had more people employed in the cotton industry than any other town, and of the towns north of Rossendale only Blackburn had achieved much importance.[2]

1. The Peak Forest Canal, connected by tramway from its terminus at Bugsworth with the limestone quarries of the Doveholes area. Cf. Fig. 203 on p. 584.

2. Cotton operatives in 1838 (Factory Inspectors' Returns, quoted by Chapman *op. cit.*, p. 151)—towns having 10 000 or more ('000 omitted): Manchester 39.4, Stockport 23.8, Oldham 15.0, Bury 13.7, Ashton-under-Lyne 12.1, Rochdale 10.9, Blackburn 10.5, Bolton 9.9. Whalley parish, that included the growing villages of Burnley and Accrington, had about 10 000 cotton workers. See H. B. Rodgers, 'The Lancashire cotton industry in 1840', *Trans. Inst. Br. Geogr.*, **28**, 1960, 135–53; also K. L. Wallwork, 'The calico printing industry of Lancastria in the 1840s', *Trans. Inst. Br. Geogr.*, **45**, 1968, 143–56.

## Modern Growth and specialisation

The main trends to be observed in the industry between the Industrial Revolution and the First World War are six in number. (1) An absolute expansion of the British output, accompanied by a decline relative to the world's total (cf. iron and steel, and shipbuilding). The only serious setbacks received until the First World War were the result (*a*) of the cotton famine brought about by the American Civil War; (*b*) of the great depression of 1873–96, during which the general economic depression, the depreciation of silver (affecting the purchasing power of Eastern countries), and the commencement of foreign competition combined to arrest the triumphant progress of the first half of the century. (2) An increased separation of the spinning and weaving branches, with the development of a 'horizontal' system of organisation. (3) An increased specialisation in the finer types of yarn and fabric, and in fabrics for special markets—a consequence of foreign competition in the production of cheap goods and of the comparatively high cost of raw material as a result of distance from its source. (4) Changes in the mode of transport, the railway superseding the canal, and then the road seriously competing with the railway for the carrying of raw cotton and manufactures. (5) The growth of associated industries, notably textile engineering and the manufacture of chemicals. (6) The beginning, in the twentieth century, of a change in the source of power, increasing use being made of electricity.[1] There is one feature which distinguishes the cotton from the woollen industry during the Industrial Revolution period, and that is the earlier mechanisation of cotton manufacture. Cotton was a well-established factory industry in the 1830s when the greater part of the wool industry, with the exception of worsted spinning, was still in the domestic stage.[2]

1. Power employed in cotton industry 1924 and 1930 (Census of Production).

| | 1924 | 1930 |
|---|---|---|
| Prime movers (steam engines and turbines) | 328 000 hp | 283 000 hp |
| Electric generators driven by prime movers | 20 000 kW | 28 000 kW |
| Electric motors and purchased current | 52 000 hp | 75 000 hp |

At the Census of Production, 1948, the cotton spinning and weaving industries were recorded as having spent £4.9m on coal and £1.8m on electric current.

2. Persons employed in textile factories (*British Commerce and Industry*, ed. J. W. Page, vol. ii, p. 230).

| YEAR | COTTON | WOOL |
|---|---|---|
| 1835 | 219 286 | 55 461 |
| 1850 | 330 924 | 154 180 |
| 1861 | 451 569 | 173 046 |
| 1870 | 450 087 | 238 503 |
| 1880 | 528 795 | 301 556 |

# The state of the cotton industry during its prosperity

## Sources of raw material

The cotton industry in Britain was founded on supplies of raw cotton from the Near East, as we have seen. Before the end of the seventeenth century, the West Indies began to rival the Levantine regions as the chief source of supply. London was the principal receiving port, most of the cotton making an overland journey between the capital and Lancashire. Liverpool, although its general trade was growing, was not important as an importer of cotton until the rise of the United States as a cotton-producing region. Towards the end of the eighteenth century Glasgow also began to import West Indian cotton. Little expansion was possible in the supply of raw cotton from these regions, however, while the French were still in a position to intercept cargoes bound for Britain, and it so happened that a fresh source of supply in the Cotton Belt of the newly established United States became available at just about the same time as the Revolution in France temporarily upset the trading and industrial activities of that country. The cotton plant was of some importance in the agricultural economy of Georgia and the Carolinas by about 1790, and the invention of the saw gin, a machine for separating the fibres from the cotton seeds, in 1793, by making the medium-stapled American cottons much more readily usable, gave the signal for a very rapid expansion of cotton cultivation. The Southern States quickly superseded all other sources of supply, and since that time their produce has been the mainstay of the British cotton industry, and every fluctuation in their crop has been reflected in the prosperity or otherwise of the Lancashire mills.[1]

Before the First World War the United States and Egypt provided about 80 per cent of the imports. Since then there has been a great decline in the actual and proportional imports from the United States, accentuated since the Second World War by shortage of dollars; and an increase in the amount received from a variety of other sources, including Turkey, Iran and the USSR. The recovery of Japan and the changed political status of India and Pakistan have reduced British imports from the Indian subcontinent (see table opposite).

Raw cotton varies enormously in quality. The important factors determining quality include length and regularity, fineness, lustre, softness, strength, colour and cleanness. The fibres vary in length from about 12 mm (½ inch) to 57 mm (2¼ inches). In America, when the fibres are less than 28 mm (1⅛ inches) in length, the cotton is referred to as short stapled; long-stapled cottons exceeded 28 mm (1⅛ inches). In other countries the terms

1. For example, the American Civil War, 1861–64 or the partial failure of the crop in 1921.

are relative. We may classify the various grades of raw cotton into three principal groups:

Group I or Fine Cottons, including:
True Sea Island, produced only in small quantities in the small islands off Georgia (United States) and in some of the smaller West Indian islands;

Georgia and Florida Sea Island, generally grown on the coast lands of those States near the sea. Of roughly equivalent quality are the finest Egyptian cottons (Sakellaridis);

American 'Long Stapled Uplands', grown mainly in Louisiana and Texas (32 mm to 45 mm: $1\frac{1}{4}$ to $1\frac{3}{4}$ inch staple). Of about the same quality are Peruvian and the best West African cottons.

Group II or American 'Uplands'—the commonest and most abundant quality. Uplands are classified according to the International (US official) standards into eight grades. In Group II are included much of the South American cotton as well as long-stapled Indian[1] and Russian.

Group III or Short Native Indian, Russian and Chinese cottons—short-stapled and harsh.

*Retained imports of raw cotton* (million lb)

| COUNTRY OF ORIGIN | 1913 | AVERAGE 1921–25 | AVERAGE 1926–30 | 1931 | 1950 | 1962 | 1966 |
|---|---|---|---|---|---|---|---|
| United States | 1471 | 857 | 838 | 442 | 329 | 152 | 78 |
| Egypt | 288 | 265 | 249 | 238 | 188 | 18 | 12 |
| India | 30 | 78 | 78 | 97 | 36[1] | 27[1] | 19 |
| Brazil | 57 | 24 | 20 | 37 | 178 | 52 | 31 |
| Peru | 38 | 72 | 83 | 64 | 62 | 36 | 27 |
| Anglo-Egyptian Sudan | -- | 12 | 45 | 10 | 97 | 52 | 20 |
| Other countries | 290 | 92 | 370 | 210 | 115 | 331[2] | 280[3] |
| Total | 2174 | 1400 | 1483 | 1098 | 1005 | 668 | 467 |
| Total (million kilograms) | 986 | 635 | 673 | 498 | 456 | 303 | 212 |

[1] Includes Pakistan, 28 in 1950, 15 in 1962.
[2] Includes Iran 50, Turkey 49, USSR 30, Nigeria 15.
[3] Includes Turkey 74, USSR 41, Iran 38, Nigeria 13.

In general, it may be said that the longer the staple of the cotton the finer the yarn and fabric that can be produced from it. Yarn is graded in 'counts'. A count is the number of hanks, each 768 metres (840 yards) in length, which go to make 0.45 kilogram (one pound avoirdupois). Thus the finer the yarn the higher the count. Ordinary American cotton of 22 mm

1. The bulk of the cotton imported by Britain from India and Pakistan does not exceed 20 mm ($\frac{3}{4}$ inch).

($\frac{7}{8}$ inch) staple will produce yarn of about 20's counts, but the best Sea Island may give a yarn of almost spider's web fineness, counting 825 hanks to the kilogram (more than 300 hanks to the pound), and counts of up to 200 are produced from the best Egyptian cottons.

## Processes in the Cotton Industry[1]

The principles of cotton manufacture resemble those which we have already described for the woollen industry (p. 508). The main processes are as follows:

(*a*) After unbaling the raw cotton is passed through mixing and cleansing machinery (in which spiked rollers and air suction play important parts).
(*b*) Next, the carding machines give a final cleansing, remove the short unusable fibres[2] (see below) and deliver the cotton in slivers—ropes of clean separated fibres, held together by their natural cohesion.
(*c*) In order to remove irregularities of thickness and weight, several slivers are combined in a 'drawing-frame' and drawn out into one, so that the fibres take up a position parallel to each other.
(*d*) The drawn slivers are passed through a succession of machines (fly frames) which gradually reduce their thickness and prepare them for receiving the twist which will make them into yarn.
(*e*) One of two methods may be used in the spinning process. The simplest apparatus is the ring-frame (derived from Arkwright's water-frame), which spins continuously and is used chiefly for warp and coarser yarns. More complicated, needing more attention (for its operation is intermittent), but producing softer and better yarn, is the self-acting mule (derived from Crompton's invention).
(*f*) 'Doubling' (twisting together of spun yarns) may be performed to ensure an even count being produced or to give strength to warp yarn; and all yarn destined for use as sewing thread, or in the lace and hosiery trades, is doubled.
(*g*) Weft yarn needs little or no further preparation, but the 'twist' (warp yarn) must be transferred from the cops or bobbins of the spinner on to a winding frame ready for assembling on the warper's beam.
(*h*) After 'beaming', the yarn on the beams is passed through boiling size and steam dried.
(*i*) The beam is then mounted in the loom, and weaving can commence.
(*j*) The 'grey' woven cloth is then either disposed of as such, or is subjected to several finishing processes. Apart from dyeing, bleaching and printing, the more important of these are calendering and mercerising. The calendering machine gives a smooth and shiny finish to the cloth. Mercerising con-

1. See *The Cotton World*, ed. J. A. Todd, 1927, p. 191.
2. In the production of fine yarn from long-stapled cotton special combing machinery is employed for this purpose between the carding and drawing processes.

sists of steeping cotton yarn or cloth in a bath of caustic soda in such a way that the shrinkage which would ordinarily result from such treatment is prevented. It produces a lustre almost equivalent to that of silk.

The short fibres removed by the carding machines are known as waste. They are worked up (sometimes mixed with short-stapled Indian cotton or even with wool) into coarse yarn (5's to 10's counts) for use in the manufacture of sheetings, blankets, towels, dusters, lamp wicks and a host of other miscellaneous products.

## Geographical distribution and its background

(*a*) *Lancashire*. In analysing the factors which have contributed to the remarkable concentration of the cotton industry in Lancashire we must attempt to differentiate between true localising factors, i.e. factors which were responsible for the placing of the industry just where it is, and factors which have merely been assets in confirming that localisation and in hindering any serious migrations into other regions. In the first category we have the historico-geographical influences already dealt with—the physical environment which aided the rise of woollen and linen industries on the western flanks of the Pennines (cf. Chapter 19), and the part played by Manchester, as a non-corporate town, in attracting industry to itself. In the first class, too, are the water power provided by the numerous steeply graded streams and the soft, lime-free character of the water of those same streams. The combination of lime-free water and water power was the most powerful factor in determining the location of the individual producing centres and the boundaries of the cotton-working region. Of the second class, first and foremost is the existence of productive coal measures. Lancashire could scarcely have attained to its present position had it not been for the coalfield; the industry would probably have died a natural death before the middle of last century. Other important auxiliary factors are the naturally high humidity of south Lancashire, which reduced the necessity for expenditure upon humidifying apparatus for spinning mills; the proximity of the Cheshire saltfield, providing essential materials for the bleaching industry; and the facilities for rail, water and road communication offered by the natural routeways of the Pennine and Rossendale streams, and by the flat plain of southwest Lancashire between Manchester and Liverpool.

The physical setting of the industry has already been alluded to; let us now examine it in rather more detail. The core of south Lancashire is the Rossendale anticline, trending in a westsouthwest direction from the monoclinal axis of the Pennines. On the north side of the upland are the towns situated in the valleys of the Darwen and Calder, tributaries of the Ribble; south of the upland are the towns in the middle Irwell and Roch valleys; and in the denuded heart of the upfold lie the towns strung along Rossendale, the upper valley of the Irwell. The fourth group of cotton-working

centres lies in the valleys of the Medlock, Tame and upper Mersey, which flow down from the Pennines (Fig. 194). The Pennine region and part of the Rossendale upland are made up of the thick Millstone Grit Series, and the flanks of the latter are composed mainly of Lower Coal Measures. These systems are characterised by similar lithology, consisting mainly of hard sandstones (hence forming uplands) with alternations of shales and porous

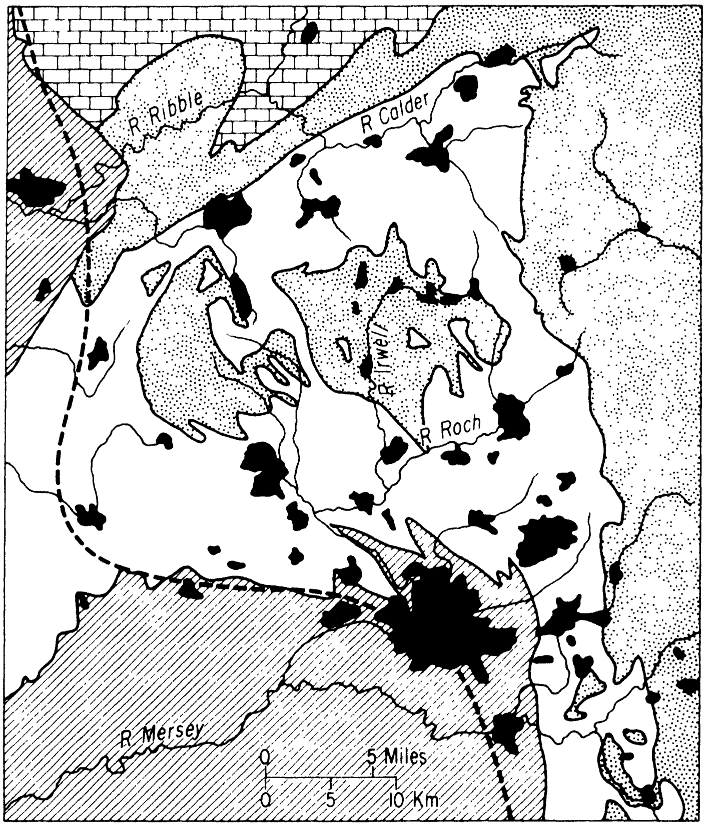



FIG. 194. The cotton-working towns of Lancashire, showing the relation of their position to geological outcrops and soft-water supplies

Carboniferous Limestone outcrop shown on the north; Millstone Grit, dotted. Coal Measures, blank; Trias, lined. The heavy broken line marks the westward limit, according to H. W. Ogden, of public supplies of soft water (hardness under 10); the water used by the mills, however, was often much less pure and of poorer quality.

grit beds (and in the latter formation some coals). They therefore give rise to an abundance of lime-free surface water and although, owing to their low porosity, they are not good water *bearing* formations, the deep narrow valleys which dissect the uplands could easily be dammed in order to ensure copious and constant supplies. The regularity of the stream regime is a

result of the comparative evenness of the precipitation through the year (partly, no doubt, due to orographical influence on the rainfall in a west-facing upland area) and of the thick accumulations of spongy, water-holding peat which cover the moors.

The extent to which the need for soft water, at first for washing and cleaning, bleaching and dyeing, and later to an even greater extent for the chemical bleaching process and for the steam-producing boilers, limited the outward expansion of the industry, is seen in Fig. 194. Water having a permanent hardness of more than 10 degrees (i.e. 10 grains of carbonate of lime, or its equivalent in other lime or magnesium salts, per gallon of water) is very difficult to lather, and this makes for much wastage of soap and chemicals; moreover, the excess of lime is deposited as scale in the boilers and pipes of the power-producing plant. Although water-softening apparatus became available, the cost of installation and upkeep was not likely to assist in the construction of new mills outside the soft-water area. We thus find that the cotton industry did not develop on the Triassic, drift-covered area of southwest Lancashire, nor on the flanks of the limestone Pennines; the absence of water power in the former region provided a further check to the westward expansion of the industry. The northern boundary of the cotton-working region is probably the result of the interaction of several factors. The more diversified lithology of the rocks underlying the Ribble basin, together with the fact that the Ribble itself rises in one of the most extensive areas of limestone in northern England, render the softness of the water less reliable. Moreover, two further hindrances to northward expansion were the absence of coal and the distance from the economic centres of the industry—the port of Liverpool and the Manchester market. Thus, north of the coalfield edge, the only two cotton-working centres of any importance are Preston (deriving its soft water from the Millstone Grit of Longridge Fell) and Clitheroe (similarly supplied from Pendle Hill). Finally, it is noteworthy that the cotton industry overstepped the flat watershed between the Roch and the Yorkshire Calder, Todmorden and Hebden Bridge being far more devoted to cotton than to wool.

The importance of soft water must not be overemphasised, except as an original locating factor. As the nineteenth century advanced the water supplies of the individual mills were often polluted and the hardness of the water increased. Further, many of the ordinary spinning and weaving mills had little use for water except for their steam engines, whilst the substitution of electric power still further reduced the water requirements. The industry went on growing through its own momentum, not because of sott water.

Concerning the coalfield as a factor in the growth of the industry, reference has already been made (Chapter 14) to the nature and occurrence of the seams. It is noteworthy here that the major centres of production were never in the vicinity of the principal cotton towns, but lay southwest thereof, in the Lancashire plain. The Bolton–Rochdale group, and the Rossendale

group, especially, are removed from large mines. It is obviously, then, the mere existence of the coalfield, rather than the geographical distribution of the mining centres, which was of importance (cf. Chapter 19, p. 516, and Fig. 121). Since the Second World War the almost universal use of electric power from the grid has completely removed any dependence on the coalfield.

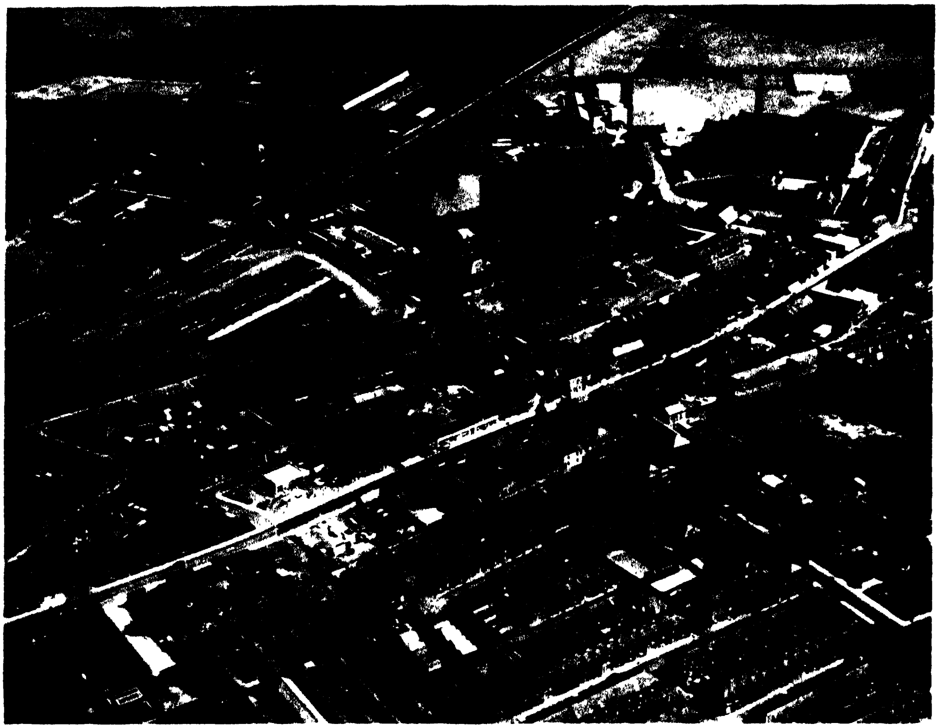


PLATE 23. A Lancashire cotton-mill town: Shaw
Typical mill buildings, mingling with nineteenth-century 'bye-law' housing

The humidity of the atmosphere in Lancashire, although not the vital factor that it was formerly supposed to be, was a valuable asset.[1] For spinning a high relative humidity is required, as otherwise the threads snap under the strain put upon them in the process of drawing and twisting. Dampness causes the fibres to cling together. Even a slight drop in the relative humidity, due perhaps to an east wind, was sufficient to cause considerable inconvenience, and a long dry spell might have proved very costly. From very early times, however—almost in fact from the introduction of the steam engine—artificial steaming or humidifying of the atmosphere was practised.

1. Ogden, *loc. cit.* (above, p. 527).

Finally, a last result of the geological structure is the abundance of building material, so necessary in an area where great factories had to be erected. The sandstones of the Millstone Grit and Coal Measures were employed for domestic and factory architecture, and later the Coal Measure shales were dug in large quantities for brick making. Whilst the older spinning mills, and most of the weaving 'sheds' north of Rossendale, were built of buff-coloured sandstone (now much soot-blackened), most of the modern mills are redbrick buildings,[1] which with their three or four storeys, chimney and tower stand out prominently and give an occasional splash of colour to an otherwise drab landscape (Plate 23).

The development of associated trades is a natural accompaniment of the growth of any large and concentrated industry. It was indeed fortunate for the cotton industry that the principal seat of the heavy chemical industry in Britain should have grown up in the middle Mersey region, backed on the one hand by the saltfield of Cheshire, and on the other by the port of Liverpool, through which were imported the fats for soap making and the pyrites for sulphuric acid. Probably at first the two industries, cotton and chemicals, were interdependent, but the vast expansion of the chemical industry resulted in the textile trades forming only a small part of the market for the produce of Widnes, Runcorn and Northwich (cf. Chapter 22). The growth of the engineering industry, too, especially that part of it devoted to the manufacture of textile machinery, was a natural corollary of the early inventions. Without it Lancashire could never have continued to lead the world in technical efficiency and in the production of the finest types of cotton fabric (cf. Chapter 17, p. 439).

The cotton industry would likewise have been stifled through the inadequacy of its transport system had not the railway come to its aid. The bulk traffic engendered by the cotton trade quickly outgrew the capacity of the canals, and the monopolistic control exercised by the canal owners, the slowness of the transport, and the endless delays due to the locks, and in summer to lack of water and in winter to ice, led a group of merchants in Liverpool and Manchester to embark on the construction of the railway to connect those two industrial foci (cf. Chapter 26, p. 698). In the 1830s the high-water mark of canal transport was reached; then railways began to supersede the stage coach and the barge for passenger and freight traffic, and by 1850 almost all the present railways were in existence. The outstanding features of the railways web of south Lancashire were a reflection of the distribution and organisation of the cotton industry—although, of course, it was not the cotton industry alone which produced them. No less than three main lines connected the market and the port—the direct route across Chat Moss, the southern line *via* Warrington, and the northern line via Bolton. Manchester had a radial web linking it with all the major centres (see Fig. 243, p. 703), and an important link joined Liverpool to the

1. The bricks, which have a smooth, shiny surface, are known as 'Accrington reds'.

weaving centres of East Lancashire. A later expression of the dominating position occupied by Manchester was the Ship Canal, completed in 1894, permitting large ocean freighters to dock thirty-five miles inland from the Mersey Bar.

Mention should finally be made of the expansion of road transport between the ports, the mills and the market. Motor lorries, by reason of their greater flexibility as transporting media, have taken much traffic from the railways. Loading up with raw cotton at the Liverpool or Manchester docks, they can deliver at almost any spinning mill within an hour or two, and are then free perhaps to carry yarn to a weaving mill, and afterwards cloth back to the Manchester warehouse in the same day.[1] Such mobility and speed are impossible for a railway wagon.

*Ports importing raw cotton* (million lb)

| | 1913 | AVERAGE 1927–30 | 1931 | 1935 | 1948 | 1961 | 1967[1] | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | MILLION LB | MILLION KG |
| Liverpool | 1690 | 1106 | 744 | 855 | 652 | 380 | 330 | 150 |
| Manchester | 383 | 336 | 338 | 425 | 210 | 120 | 118 | 54 |
| London | 40 | 22 | 13 | 33 | — | 5 | | .. |

[1] Also Glasgow 2.5, Belfast 4.7 million lb.

(*b*) *Scotland.*[2] The growth of a cotton industry in Scotland, although resting on sound geographical foundations, was largely the result of the coincidence, in time, of two events of historical importance. At the beginning of the Industrial Revolution period flourishing linen and silk industries were already in existence, being especially well developed in the Glasgow–Paisley region (cf. Chapter 21). Abundant supplies of soft water from the lime-free rocks of the Central Lowlands, a humid atmosphere favourable to the spinning operation, and a 'deposit' of labour skilled in the manufacture of fine fabrics, thus provided a suitable ground in which the new industry could take root. Then the American War of Independence, by causing the sudden ruin of Glasgow's extensive trade with the Plantations—especially the tobacco trade—left without employment a vast amount of capital and organising ability which had been gained therein; and it so happened that this period, 1775–80, coincided with the period of the great inventions in the cotton industry which we have already discussed. The manufacture of cotton thus provided a very appropriate new outlet for the capital and skill of the Lowlands. Actually, the use of cotton in fustian

1. It has been calculated (W. Smith, 'Trends in Lancashire cotton industry', *Geography*, **26**, 1941, 7–17) that on the average no fewer than six journeys are undertaken from raw cotton to finished piece-goods.
2. See H. Hamilton, *Industrial Revolution in Scotland*, Chapter 6.

making probably began about 1769, and in 1780 muslins began to be made, using Indian spun weft; but it was not until the early 1780s that the use of Crompton's mule enabled all-cotton cloth to be made from homespun yarn, and the real boom in the erection of cotton spinning mills occurred between 1785 and 1795.

The widespread nature of the linen industry and the abundance of soft water and water power in most parts of Scotland resulted in the early cotton mills being scattered in many counties, although the Glasgow region naturally exercised a considerable influence on the location of new enterprises,[1] by reason of its West Indian traffic (most of the cotton came before 1795 from these islands) and its linen and silk trades. With the exception of one or two well placed concerns which managed to survive for a considerable period, however (e.g. Catrine in Ayrshire, Deanston in Perthshire—both of which still exist today), most of the mills outside the Glasgow–Paisley region were comparatively shortlived; distance from the source of raw material (i.e. the port), and later from coal supplies, causing their eventual demise.

Just as in Lancashire, a new factor was introduced into the industry in the 1790s—the steam engine. The expansion of this method of power production was not rapid in Scotland, partly because of the excellent water power facilities which were being utilised, and partly because the engineering industry did not establish itself on the Lanarkshire coalfield as rapidly as in Lancashire, each new mill thus having to make its own machinery. Slowly but surely, however, the steam engine conquered the spinning industry, and the concentration of the mills upon the Lanarkshire coalfield became more marked. By the 1830s nearly all the spinning mills were to be found within 40 kilometres (twenty-five miles) of Glasgow.[2]

In the weaving branch, of course, domestic labour continued to produce the greater part of the output for some time after the spinning industry had been mechanised, and, as in Lancashire, the weavers enjoyed a period of great prosperity whilst yarn was so cheap. In 1831, although there were nearly 15 000 power looms in the Glasgow district, some 50 000 hand looms were still in use in the villages of Lanarkshire, Renfrew and Ayrshire, and hand-loom weavers remained an important section of the community until the 1870s or 80s. The early specialisation of the linen and silk industries in fine fabrics naturally gave an impetus to the production of similar fine wares in cotton. Muslins and ginghams were the ordinary goods produced, but over half the looms, in about 1840, were employed in making the famous Paisley shawls (either all cotton, or cotton and silk), fancy muslins and

1. The first cotton mill in Scotland was erected at Rothesay on the island of Bute in 1779. In 1787 there were nineteen water power spinning mills, distributed as follows: Lanark 4, Renfrew 4, Perth 3, Edinburgh 2, Ayr 1, Galloway 1, Annandale 1, Bute 1, Aberdeen 1, Fifeshire 1.

2. Spinning mills, 1839: Lanarkshire 107, Renfrew 68, rest of Scotland 17. Glasgow alone possessed 98.

decorated cloths. Here lay the greatest difference between the cotton industries of Scotland and Lancashire. Lancashire was thriving on coarse cotton cloths for the Indian market; the fine fabrics from Glasgow went mainly to the continent.

The rapid rise of the cotton industry and its concentration in the Glasgow region were accompanied, as in Lancashire, by the growth of auxiliary trades. Pure water supplies and the facilities for importing raw materials gave rise to a chemical industry which could supply the bleaching and dyeing works which naturally sprang up in the wake of the cotton mills.[1] The ease of production of iron and coal resulted in the establishment of an engineering industry; but although at first this may have been intimately connected with the cotton trade, it soon expanded far beyond the limits set by the mechanical requirements of the factories, and took to the railway and shipbuilding branches (cf. Chapter 17, p. 452). It was the extraordinary geographical basis of the iron industry, in fact (cf. p. 399), which prevented Glasgow from becoming a rival to Manchester, and which was largely responsible for the gradual decline of the Scottish cotton industry in the second half of last century. Iron, and later steel, came so to dominate the economic life of the lowlands, especially of the Lanarkshire coalfield region, that the cotton industry, built from the very beginning on the rather insecure foundation of specialisation in fine and peculiar wares, and so susceptible to changes of fashion,[2] and unable to take advantage of the expanding Indian and Far Eastern markets, was almost swamped.[3] The geographical suitability of the area for cotton manufacture remained unaltered, but the far greater suitability for iron and steel production resulted in the concentration on these trades at the expense of cotton. Such industry as remained was located off the coalfield, as in Glasgow, Paisley and in the Leven valley.

## Specialisation

The extraordinary centralisation of the cotton industry in south Lancashire rendered possible a degree of specialisation that is without parallel in any other branch of manufacture. Not only have the various processes of the industry tended to separate, financially and physically, but the relatively unfavourable situation of Lancashire with regard to raw materials and foreign markets produced a further specialisation in the finer varieties of fabrics and in products for particular markets. The focus of this centralisation from the very beginning was Manchester; but from being the principal producer the city changed its role to that of commercial and financial centre. An industry which imported all its raw material from abroad and

1. The dyeing industry was introduced into the Glasgow region by James Watt, who brought Berthollet's invention from France. (Cf. pp. 531, 579.)

2. The manufacture of Paisley shawls, for example, collapsed between 1870 and 1880.

3. See Hamilton, *Industrial Revolution in Scotland*, pp. 147–9.

exported the bulk of its output naturally needed a greater amount of commercial organisation than an industry based upon local supplies and local markets; and Manchester, excellent route centre that it was, assumed the functions of bank and warehouse. The rapid growth which such a position entailed, combined with the city's increasing importance as a port, had the effect of raising land values to such an extent that many of the older mills migrated to the outer suburbs and to the smaller towns. Manchester is still the centre of the industry—no longer the producing centre, but the commercial centre.

Two of the outstanding features of the Lancashire cotton industry were the extreme specialisation of its constituent parts, and the feeble development of integration of any kind. At least six types of firm could be recognised: (*a*) the Liverpool merchants and brokers; (*b*) the spinners; (*c*) the yarn merchants; (*d*) the manufacturers (weavers); (*e*) the dyers and finishers; (*f*) the piece-goods merchants. Many of the producing firms further limited their activities, confining themselves, for example, to fine or coarse yarn, special fabrics, bleaching, sizing, or dyeing; whilst the activities of the Manchester merchants were similarly limited to certain markets.[1]

The distribution of the three main branches of the cotton industry, spinning (including carding), weaving or 'manufacturing' (including winding), and finishing (bleaching, dyeing and calendering) is indicated graphically in Fig. 195.[2] The 'combined' mill, doing both spinning and weaving, was the dominant unit of the industry until well on in the nineteenth century, and it never completely disappeared, but the economic basis of the separation of spinning and weaving, apart from the historical reasons given above, is not difficult to discover. It was due to two main causes. In the first place it was the result of the ever-increasing range of yarns and fabrics which could be produced. Few firms, without being unwieldy and uneconomic, could possibly manufacture all the many varieties of yarn and stuff, and so the business units tended to remain small, specialising in certain types of product only. Secondly, the organising capacity necessary in the spinning industry was very different from that required in weaving.[3] The spinning branch was concerned with a narrower range of products, was more adaptable to large-scale production and horizontal integration, and depended for its market not only on the local weaving industry, but also upon the fairly stable cotton industries of the continent, and to an increasing extent upon the hosiery trades at home and abroad. The weaving trade, on the other hand, dealt in a multitude of different

1. Chapman, *op. cit.*, Chapter 8; G. C. Allen, *British Industries*, 1st edn, pp. 227–50; *Survey of Textile Industries*, pp. 15–30.
2. For an alternative method of demonstrating the distribution of spinning and weaving, by plotting the location of factories, see Fig. 62 of Wilfred Smith's *Economic Geography of Great Britain*, Methuen, 1949.
3. Chapman, *The Lancashire Cotton Industry*, pp. 161–4; cf. Jewkes, *Econ. Hist.*, **2**, 1930, pp. 105–6.

styles of fabric, employing many different types of yarn, and depended largely for its prosperity upon a fluctuating, almost worldwide, market and upon the ability to foresee and cater for changes of fashion, both at

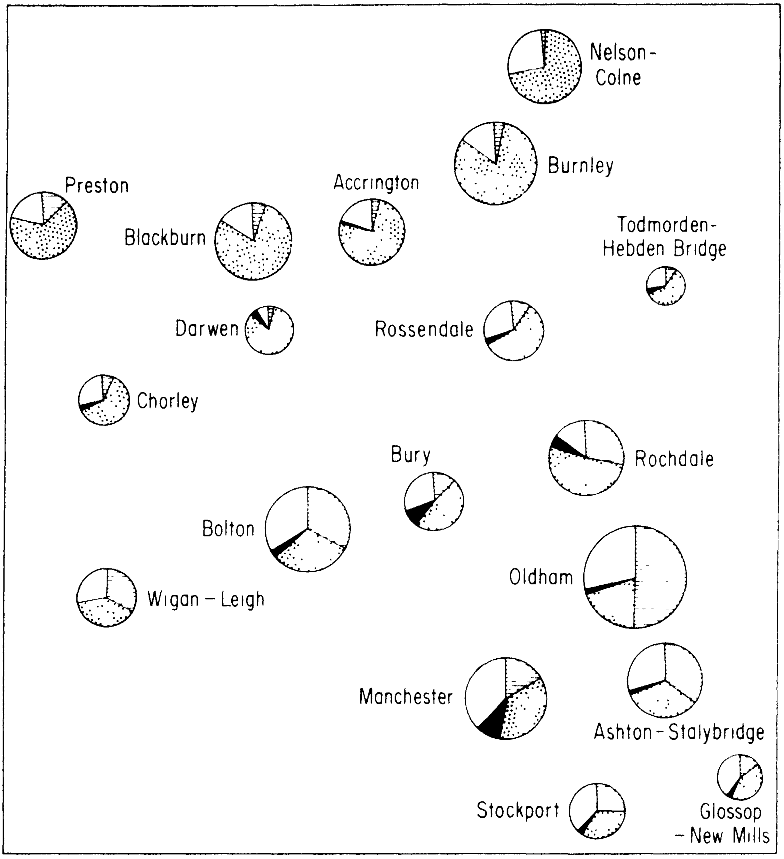



FIG. 195. Distribution of textile occupations in the cotton-working area, 1921

Circles are proportional in area to number of people employed; thus Oldham = 66 000, Darwen = 13 000. The sectors of the circles represent the proportion of the total engaged in the various branches of the industry. Ruled = Carding and Spinning (Census groups 363,365), dotted = Winding and Weaving (groups 367,370); black = Dyeing and Calendering (groups 381,384); blank = all other cotton-working occupations. The people have been grouped around the principal towns; thus Bolton includes Bolton C.B., and the parishes of Farnworth, Kearsley, Little Lever, Turton and Little Hulton; Rossendale includes Bacup, Rawtenstall, Haslingden and Ramsbottom. Notice the feeble development of spinning in the northern area, the prominence of weaving in the so-called 'spinning' area of the south, and the importance of the finishing trades in the Manchester-Bolton-Bury region.

home and abroad. There were still many firms which, whether through sheer momentum, or through the desire to ensure the quality of the yarn which they used, conducted both spinning and weaving operations, but the majority confined themselves to one branch only. The number of

separate firms engaged in weaving was much greater than the number in the spinning trade. This was partly due to the greater tendency for amalgamation amongst spinning firms and partly to the extreme specialisation of the weaving trade.[1]

The spinning industry continued to be located principally in the towns of the early cotton-working area—the region of the valleys tributary to the Irwell and the Mersey, i.e. to Manchester. Although the 'horseshoe' of towns stretching from Wigan and Leigh *via* Bolton, Bury, Rochdale, Oldham and Stalybridge to Stockport was primarily devoted to spinning, weaving was by no means absent, and the spinning industry showed much specialisation incapable of geographical explanation. Thus Oldham dealt mainly in medium staple American cotton, producing yarn of 20s to 60s counts. Rochdale's trade was similar. Bolton and Manchester, on the other hand, spun finer yarns from the best American, Egyptian and Peruvian cottons; and in the Stockport district doubling became an important separate branch of the industry. North of the Rossendale upland spinning was of very small importance compared with weaving.

The spinning district—in which about 90 per cent of all the spindles were located—suffered less during the depression of the 1930s than the weaving district, partly because of the additional outlet provided by the hosiery trades and partly since it was within this district that the bulk of the engineering and other industries of south Lancashire were located (cf. pp. 449, 487).

The weaving industry was far more widespread than the spinning, and was less concentrated in the major towns. There were many small weaving sheds outside the urban areas. Besides being dominant north of Rossendale, weaving employed as many or more people than spinning in most of the towns south of the upland, with the exception of Oldham.[2] Here again there were certain towns devoted to certain types of fabric. Within the Manchester province perhaps the chief weaving activity was concerned with the manufacture of goods from 'waste', as at Rochdale and Heywood and in the Stockport–Stalybridge districts, but Oldham still retained something of the old fustian trade, and Bolton produced quilts. The towns in the Rossendale valley specialised in sheeting (made mostly from 'waste'). North of the Fells Preston made fine shirtings, Blackburn and Accrington concentrating mainly on 'dhooties'[3] and other cheap cloths for the Indian and Chinese trade, Burnley on long lengths of narrow cloth destined for printing, Nelson and Colne on 'fancy' fabrics such as sateens, poplins and brocade.

The finishing industry, comprising bleaching, dyeing and calico printing

1. Number of firms engaged in 1924 (*Worrall's Directory*, quoted in *Survey of Textile Industries*, pp. 24–6), spinning only: 620; spinning and weaving: 232; weaving only: over 900.
2. In 1936 some 74 per cent of all the looms were in the main weaving district and 26 per cent were located within the spinning district (W. Smith, *Geography*, **26**, 1941, p. 13).
3. Long, narrow strips of flimsy cloth worn by male Hindus as pantaloons.

and numerous finishing processes, such as mercerising and calendering, remained centred in the Manchester province where it originally grew up.[1] It had been held there by the favourable situation with regard to pure water supplies, and by proximity to the great warehousing centre. The works were to be found alongside the streams which flow down from the Rossendale Fells and the Pennines, the rivers Goyt, Roch, Irwell and Bradshaw Brook being especially important in this respect. The chief centres were Manchester–Salford, Stockport, Bury, Bolton and Rochdale (with Littleborough) and the smaller towns just north of Manchester—Radcliffe, Whitefield and Middleton.

Those centres of cotton manufacture lying just off the edge of the main region in Derbyshire and Yorkshire for the most part resembled, in their industry, the Lancashire region which lay nearest. Thus the Glossop–New Mills group in northwest Derbyshire was devoted, like Stockport, to spinning, to the weaving of cloth from waste, and to the bleaching and dyeing industry. Farther north the Saddleworth–Dobcross area had specialities more akin to those of Oldham. A great tongue of the cotton industry stretched from Rochdale into the Calder valley of the West Riding, and whilst Todmorden and Hebden Bridge were more 'cotton' than 'woollen' towns, numerous woollen centres farther east also engaged to a certain extent in the manufacture of cotton.[2] Huddersfield and Halifax were the chief of these, but Sowerby Bridge, Elland and Brighouse each had more than ten firms engaged in the cotton industry. The main branches were cotton-doubling and weaving. Spinning did not develop to any extent, possibly owing to the lower average of relative humidity on the eastern side of the Pennines. Farther north still, the weaving industry of Nelson and Colne overflowed into the Aire valley. Skipton was the principal centre, but Bradford also had a number of cotton mills, and others were scattered in the small towns which lie in the valley between these two—e.g. Keighley and Bingley. In this region weaving, especially of the Nelson–Colne specialities, was the principal activity.

Rather farther afield we find interesting 'outliers' of the cotton industry in the region around the southern end of the Pennines, where the manufacture survived because of the existence of allied industries. Scattered mills in the Macclesfield district of Cheshire dealt in spinning and doubling and especially in bleaching, dyeing and mercerising, the presence of the silk industry probably having encouraged the last-named activity. In Nottinghamshire, Leicestershire and Derbyshire, the existence of the lace and hosiery trades had much to do with the survival, as at Nottingham, Derby, Mansfield, Long Eaton and a few smaller centres, of cotton doubling and the manufacture of sewing thread.

1. About one-half of the 73 000 workers in the textile finishing trades in 1948 were in the Northwestern Region.

2. Employment in the Yorkshire Region, 1948 (Census of Production): 7542 in cotton spinning and doubling, 7650 in cotton weaving.

The cotton industry in Scotland is but a shadow of its former self. The spinning branch has almost disappeared (except, of course, for the important manufacture of sewing cotton), and yarn is now obtained from Lancashire. Three types of activity remain. The last witness of the former trade in high-quality goods is the manufacture of poplins, muslins, ginghams and fine shirtings, still carried on in Glasgow. Paisley shawls have given place to sewing thread in the making of which some 8000, mostly women, are employed.[1] Lastly, the finishing trades still retain some of their former importance in the Glasgow region,[2] in the Vale of Leven (calico printing), and in north Ayrshire, by reason of the abundance of pure water and the proximity of the chemical industry—although most of their work is now performed upon fabrics which have been woven in Lancashire.

A few mills at Belfast continue to spin cotton, chiefly for admixture with flax in the production of special types of thread and table linen.

In the Irish Republic the cotton industry is mostly of recent origin, post-1930, and has been established partly in connection with the general industrialisation programme to help solve the unemployment problem and partly to reduce dependence on imports. The largest mill is at Athlone, but there are also several in the area between Dublin and the Ulster border (e.g. Slane, Ardee and Drogheda) and several in the far west in Co. Galway.

## The present state of the cotton industry

Since 1913, the peak year of the cotton industry, in numbers employed and in production, there has been a marked contraction in all aspects of the industry. It is true that there have been some relatively prosperous years since then, such as 1925, 1937 and 1951, but these have only been temporary halts in the overall gradual decline.

Over the past half century, such is the completeness of the decline that in 1961 the volume of British cloth exports was a mere 5 per cent of the maximum of over 6500 million metres (7000 million linear yards) reached in 1913, and cotton manufactures represented but 1.5 per cent of the total value of UK exports, compared with 25.6 per cent in 1913. Indeed, by 1958–59 the yardage of exports was actually exceeded by cheap imports from Asia, and in 1960 the UK became a net importer of cotton yarn. By 1967 one-third of the home market for cotton goods was being supplied by imports. The main reason for this sad state is primarily the loss of overseas markets, especially in the Far East, where the rapidly growing industries in Japan, Hong Kong, India and Pakistan have entered the world cotton trade as well as supplying their own large home markets. Secondly, the industry

1. Enough thread is made each week in Paisley to encircle the earth 88 times! Employment, 1953: 8436, of whom 5672 were female.
2. Nearly 13 000 people were employed in Scotland in textile finishing trades in 1948. The Vale of Leven industry is much declined, and a new industrial estate has come into being to relieve the unemployment thus created.

has been hampered by the accumulation of redundant and obsolete equipment; the poor trade prospects have discouraged mill owners from modernising their plant and keeping up-to-date with modern techniques. A third factor contributing to the decline has been the shortage of labour. In view of the general contraction of the industry this needs some explanation. During the 1939–45 war many mills were compulsorily closed as the industry was geared to war production. Some of the abandoned premises were used for other purposes, munitions and engineering products, many of the new occupying firms having moved from the more vulnerable Midlands and south of England. Thus many cotton operatives found employment in alternative trades and of course many were drafted into other occupations away from their home region. The dying industry did not attract them back again and thus the United Kingdom was unable to take full advantage of the great demand for goods immediately after the war. The seller's market was lost, and then European and Far East manufacturers quickly recovered to take the trade.

The brief economic slump of 1952 hit the cotton industry severely. A considerable amount of the export trade in quality cottons, the United Kingdom's speciality, was lost to competitors in Western Europe and the United States. The prewar loss of markets for the cheap cotton goods continued and the growth of imports upset the balance of trade still further. Grey cloth has featured among the imports for some time, and much of it was re-exported after finishing in British mills, but in 1958 for example, 65 per cent of this was sold on the home market. The following year, the government attempted to rectify affairs with the Cotton Industry Act 1959. The Act aimed at drastic reorganisation of the industry in two ways; first, the government was to compensate firms who scrapped obsolete equipment and secondly, it would provide grants to help with the cost of installing new machinery. The voluntary application of the Act brought about great changes. In the first year, 40 per cent of the installed looms and 49 per cent of the installed spindles were scrapped. However, much of this equipment had been redundant for a number of years. Of much more significance is the fact that 81 per cent of the looms scrapped were in mills which closed down completely whereas only 56 per cent of the scrapped spindles were in closed mills. Thus, it could be expected that less re-equipment would result in the weaving mills, the branch of the industry on which the country depended for its specialised products to overcome overseas competition. Fine spinning and fine weaving, the manufacturing of good quality cotton goods had also suffered a setback from the rapid development of the manmade fibre industry. Rayon at first, followed by nylon, Terylene, Dacron, etc., have all helped to replace some of the traditional cotton manufactures. Many mills have turned to yarn mixtures, and the reservoir of facilities and skill in the cotton manufacturing areas has meant that factories producing artificial fibres alone have been established in Lancastria. But they are by no means dependent on the facilities and advantages of the region, for nylon and

Courtelle factories are found in many parts of the country, encouraged by more favourable amenities to go to the new light industrial estates in the other Development Areas. Thus it is the fine-spinning town of Bolton for example and the fine-weaving centre Nelson that have suffered from the contraction. On the contrary, the towns of Bury and Rochdale and the small centres in the Rossendale valleys specialising in coarse products have escaped such serious losses; a complete reversal of the effects of the decline in the 1930s.

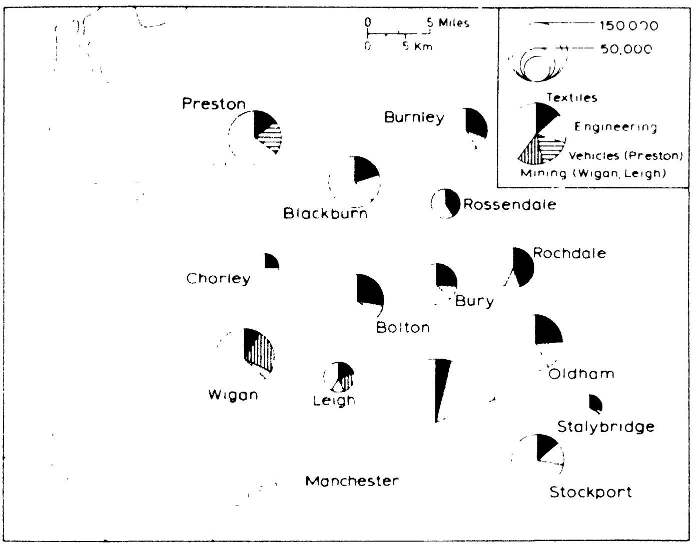



FIG. 196. Employment in textiles and other industries in south Lancashire, 1961

The symbols represent the towns named and their smaller neighbours

The result of the recent changes has been a more marked redistribution of weaving than spinning. The traditional weaving belt of the Darwen-Calder valley has now less than half of the looms in the industry, the spinning area of southeast Lancashire has gained nearly a quarter of the looms, but has maintained its lead in spinning with 75 per cent of the spindles. The old subdivision of the cotton manufacturing area into weaving predominant in the north and spinning in the south is more realistically altered to give a fourfold division suggested by H. B. Rodgers (1962): (*a*) The Darwen–Calder valley zone, still highly specialised in weaving, but comparatively less important; (*b*) southeast Lancashire, still dominant in spinning but, with the greater loss in spindles, spinning and weaving are more balanced; this is still the most important 'finishing' area; (*c*) Rossendale, where spinning and weaving are roughly equivalent and the area has experienced much less contraction in the industry than others; (*d*) West Central Lanca-

shire, where there is no marked specialisation and contraction has been small.

*The cotton industry 1956 and 1966*

| | | 1956 | 1966 |
|---|---|---|---|
| | | (IN MILLIONS) | |
| Raw cotton imports | tons | 335 | 209 |
| | metric tons | 340 | 212 |
| Cotton yarn production | lb | 597·5 | 368.2 |
| | kg | 271 | 167 |
| Cotton waste yarn | lb | 104.9 | 87.7 |
| | kg | 47·5 | 39·7 |
| Spun manmade fibre yarn | lb | 99 | 89.8 |
| | kg | 44·9 | 40.7 |
| Yarn consumed in weaving | | | |
| cotton yarn | lb | 443·6 | 248.2 |
| | kg | 201.2 | 122.6 |
| cotton waste yarn | lb | 78 | 59·3 |
| | kg | 35·4 | 27 |
| manmade fibre yarn | lb | 227.2 | 221.6 |
| | kg | 103 | 100.5 |
| Cotton production | | | |
| cotton | linear yds | 1612 | 9·5 |
| | m | 1474 | 8.7 |
| manmade fibres | linear yds | 605 | 545 |
| | m | 553 | 498 |
| cotton/manmade mixtures | linear yds | 97 | 71 |
| | m | 88.7 | 64.9 |
| Imports of woven cotton fabrics | sq. yds | 375 | 583 |
| | sq. m | 313 | 487 |
| Exports of woven cotton fabrics | sq. yds | 385 | 152 |
| | sq. m | 322 | 127 |

In 1939 there were about 1600 cotton mills of various sorts in Lancastria. The actual total in 1951 was 1562; but by 1962 it was down to 868, and by 1968 only 635 were left. Over 900 mills had been closed, but nearly four-fifths of them were converted to new uses so that no great unemployment problem resulted, and industrial diversification was greatly assisted. By 1967, no less than 140 000 people were working in old cotton mills, and the process continues.

The Lancashire textile industry can no longer be thought of merely in terms of cotton. Between one-third and one-half of the cloth output is now made wholly or partly of manmade fibres. Moreover, the economic struc-

ture of the industry has changed fundamentally in the 1960s. True, there are still (1968) about 400 independent companies with spinning, doubling and/or weaving operations, together with about 120 finishing firms and over 800 independent converters (merchants and wholesalers). Yet about 20 per cent of these firms control some 60 per cent of the spindles and 40 per cent of the looms and employ 50 per cent of the finishing labour force, and half a dozen very big firms (Courtaulds, Coats Patons, Viyella, English Sewing Cotton, Calico Printers, Carrington & Dewhurst) dominate the industry. Vertical integration is replacing the characteristic horizontal integration of the past, and some of the big firms are far more concerned with manmade fibres than with cotton, so that the textile industry is fast becoming almost an adjunct of the chemical industry that provides the fibres (see Chapter 21)—and indeed the chemical industry's capital is being used to further development.

So, with employment in textiles down to 100 000, representing but 8 per cent of the total employed population of Lancastria, and with only 5 per cent of the school leavers in 1967 entering the industry, the whole economic geography of the region has changed almost out of recognition in a few decades. It is now dominated by engineering, chemicals and manmade fibres. Cotton is no longer king.

# 21
# The textile industries: other textiles

As remarked on p. 489, it is no longer possible to make the same clear distinction as formerly between the industries dependent on cotton, wool and manmade fibres. But silk has an interesting historical geography that is still worth examining, the knitwear industry was always dependent on several raw materials and so has not been affected in its location by the advent of manmade fibres, while the linen, jute and lace industries are still recognisable entities with highly localised distributions. It is with these, together with the production of manmade fibres (that might almost equally well fall into the chapter on Chemical Industries) that we are here concerned.

Employment figures, in so far as it is still possible to separate them by fibres and processes, have been given above, p. 490.

An examination of the geographical distribution of the various branches will show that several different types of factors have been involved in their localisation.

(*a*) In the case of linen, proximity to flax-growing areas led originally to the rise of Ireland and the Scottish Lowlands as manufacturing regions. In the Lowlands the growth of other textile occupations and of heavy industries in the west resulted in the confinement of the linen trade to the eastern region —a situation confirmed by the ease of importing flax and hemp from the Baltic countries. In Ireland the events of the Industrial Revolution conspired to localise the industry on Ulster.

(*b*) The jute industry attached itself, quite naturally, to the allied linen and hemp trades of the Dundee province. It was a Dundee manufacturer who, during a temporary shortage of hemp supplies, experimented with jute as a substitute. It has attained but small dimensions elsewhere.

(*c*) The localisation of much of the silk industry in southeast Cheshire and northwest Staffordshire is not easily explicable on a purely physical basis. Its expansion was due to the pre-existence of a textile smallware and button-making trade, combined with facilities for water power development.

(*d*) The concentration of the knitwear industry in Derbyshire, Leicestershire, and Nottinghamshire is to some extent the result of fortuitous circumstances associated with the invention of the 'stocking frame' near Nottingham, though economic factors also played a part, while the lace industry of

the Nottingham district began as an offshoot of the local hosiery industry. Although the woollen and worsted industry may have had some influence on the early growth of the knitwear industry, the development of silk and cotton spinning in Derbyshire and Nottinghamshire did not take place until the knitwear industry was well established. The growth of the silk and cotton industries in this area was partly a result of demand created by a pre-existing knitwear industry, though the local supply of cotton and silk yarn in its turn stimulated further expansion of knitwear manufacturing.

(*e*) The manufacture of 'artificial' or 'manmade' fibres, such as rayon, nylon and numerous later ones such as Terylene and Courtelle is really a chemical industry, depending in the case of rayon on imported wood pulp and cotton linters, and a very large water supply, and in the case of the synthetic fibres, on chemicals derived from coal or petroleum. But their products, 'artificial' fibres, are the raw materials of textile industries which in general have attached themselves to pre-existing textile centres, where suitable skilled labour could most easily be obtained—as in south Lancashire, west Yorkshire, the Nottingham–Leicester province, the Macclesfield–Leek district, and Northern Ireland.

(*f*) Finally, there are numerous isolated centres of the minor textile industries to be found, as in East Anglia, in the West Country, and in south-west Scotland, where certain specialities are all that remain of once flourishing trades in wool and worsted, silk, or cotton.

With the exception of the artificial fibres, which are products of the twentieth century, all the minor textile industries have long histories. Many features of their early distribution are inexplicable except by the chance settlement of Flemish or other foreign craftsmen; and the geographical and historical factors which contributed to their development in most cases have long since ceased to operate. Without going into an immense amount of historical detail, then—a task which is here impossible—it is difficult to give more than a sketchy account of their origin and growth; and many of the curious features of their distribution must be passed over merely as examples of industrial momentum.

## Knitwear

The present-day hosiery industry deals with such a variety of products that hosiery proper now forms only a relatively small part of it, knitted underwear and outer garments (such as pullovers, dresses, and costumes) providing a constantly expanding market. It seems advisable, therefore, in order to avoid confusion of terms, to designate this industry 'knitwear'. For the first 300 or so years of its existence, however, the industry was primarily devoted to the production of hose.[1] With a labour force of 126 500 in Great

1. *Victoria County History, Nottinghamshire.* ii, 352–8; W. Felkin, *History of Machine-Wrought Hosiery and Lace Manufacturers*, 1867; F. A. Wells, *The British Hosiery Trade*, 1935 (see especially chapters 1 to 3).

Britain in 1961 and a further 3000 or so in Northern Ireland, the knitwear industry is by no means insignificant in the national economy, even when compared with the cotton and woollen and worsted industries, and the knitwear province of the east Midlands, with almost 76 000 people employed in the industry in 1961, must be regarded as a major region of industrial specialisation on the same level as the cotton manufacturing region of Lancashire and the woollen and worsted region of the West Riding.

The manufacture of hosiery from worsted and silk by machinery dates from the invention of the stocking frame by William Lee, a clergyman of Calverton, near Nottingham, in 1589. It seems to have been entirely a matter of chance that the machine was invented in Nottinghamshire at this time, for unlike other major technical developments in textile machinery, it was not a response to strong economic incentives. The hosiery industry gradually began to spread in Nottinghamshire and the adjoining counties of Derbyshire and Leicestershire, possibly aided by the local production of worsted yarns from the long-woolled Leicester sheep, but it was in London that the earliest major concentration of the industry took place. Here proximity to the main centre of the silk industry and the main market for luxury goods and fashionable items of clothing was responsible for the early success of machine hosiery manufacturing. The London industry began to decline during the first quarter of the eighteenth century, and most of the machines were subsequently moved to the Nottingham and Leicester districts. The main reason for this migration appears to have been that labour costs were lower in the east Midlands than in London, so although the beginning of hosiery manufacturing in the Nottingham district was largely a matter of chance, the eventual concentration of the industry in the counties of Derbyshire, Leicestershire, and Nottinghamshire was a response to positive economic advantages.[1]

Strutt's invention of a machine for producing ribbed hose, in 1758, gave an impetus to the trade, and the development of factory cotton-spinning in the Derwent valley soon afterwards stimulated further expansion. By the middle of the nineteenth century the hosiery trade, which was still entirely a domestic industry, provided work for 100 000 people, almost all in the east Midlands. The three principal counties had become concerned with different types of hosiery. Nottingham was the first to make cotton stockings from Indian spun yarn, in 1730, and its later connection with Arkwright, Hargreaves, and the early cotton-spinning industry (cf. Chapter 20, p. 529) made it the chief cotton hosiery town, although silk was also employed to a large extent. Derby, the home of the first English silk mill (see p. 571), developed the manufacture of silk hose; and Leicester, always more concerned with long wools than with cotton or silks, specialised in worsted hosiery.

The gradual replacement of the domestic system in the hosiery industry

1. D. M. Smith: 'The British hosiery industry at the middle of the nineteenth century: an historical study in economic geography', *Trans. Inst. Br. Geogr.*, **32**, 1963, 125–42.

by factory production during the second half of the nineteenth century led to further expansion of knitwear manufacturing, as the increasing use of cotton, wool, silk, and later artificial silk, for knitted underwear, and of wool especially for outer garments, greatly extended the market for knitwear. The present-day manufacture of knitwear forms an interesting link with the cotton, woollen, silk and manmade fibre industries, for the finished or semi-finished products of those trades form its raw materials. The introduction of knee-breeches almost killed the silk hose business, but the cheapening of the manufacture of silks, and more particularly the use of artificial silk in the production of ladies' hosiery, led to a revival of this branch of the trade.

The progress of the knitwear industry in Great Britain during the past sixty years is illustrated in the following table:

*Employment in knitwear manufacturing*

| | 1911[1] | 1961[2] | 1966[3] |
|---|---|---|---|
| The east Midlands | 49 500 | 75 600 | 77 340 |
| Rest of England and Wales | 6 900 | 29 400 | 31 770 |
| Scotland | 11 400 | 21 600 | 20 930 |
| Total | 67 800 | 126 600 | 130 040 |

[1] Census Report. [2] Ministry of Labour. [3] 'Hosiery and other knitted goods'.

This shows that the general expansion has been accompanied by a reduction in the concentration in the east Midlands, though this area still remains the major knitwear manufacturing region in the country.

The 'knitwear province' of the east Midlands is shown in Fig. 197. Dominated by Leicester and Nottingham the industry is seen to be grouped about four nodes. In Leicestershire there is a concentration in and around Hinckley in the south, and another centred on Leicester and extending down the Soar valley to Loughborough and Shepshed. To the north Nottingham is the focus of the trade centred on the Erewash and Leen valleys, and another concentration exists in the Mansfield and Sutton-in-Ashfield district. At Derby the decline in the silk industry after about 1860 was accompanied by considerable expansion of knitwear manufacturing, but this tended to subside as the town's engineering activities grew; an important local specialisation in Derby is the manufacture of elastic webbing and bandages. The traditional distinction between the Nottingham district specialising in cotton goods, Derby (silk), and Leicester (woollen) is now largely obscured by the widespread use of artificial fibres. Local

specialisation still exists, however: the Hinckley area and a number of towns on the Derbyshire and Nottinghamshire coalfields tend to concentrate on ladies' stockings, Nottingham and Leicester have a larger proportion of garment manufacturers, while the dyeing and finishing section of the trade remains largely concentrated in Nottingham in the Leen valley.

Outside the main knitwear province several other centres of the industry are to be found, mainly in association with other textile trades. Several towns in Lancashire and the West Riding, such as Manchester and Keigh-

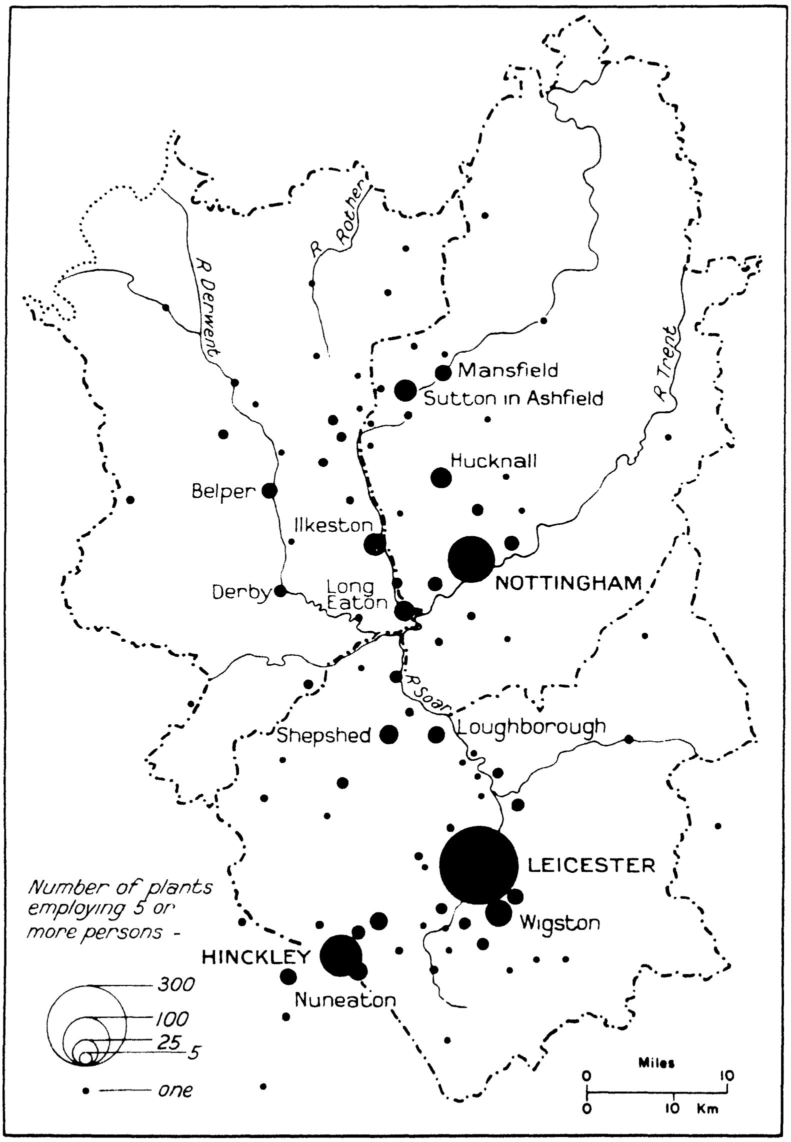



FIG. 197. The knitwear province of the east Midlands, 1957

ley, have knitting mills, as have also the silk-manufacturing centres of Cheshire and Staffordshire—Macclesfield, Congleton, and Leek. In Scotland, Glasgow, Kilmarnock, and Stewarton, together with a number of other Ayrshire towns carry on a trade which has developed out of the decayed cotton industry of the area; and at Hawick woollen knitwear, which began as a sideline to the manufacture of tweed cloth, is now the main interest, employing over 5000 people in the border area as a whole. Numerous other towns in England and Scotland have small knitwear factories, for bulky raw material is not required, and the widespread use of electric power has relaxed the restriction on location previously imposed by the need for access to local supplies of coal. An interesting development during the post-war period has been the setting up of large knitwear factories in areas of relatively high unemployment, such as South Wales, northeastern England, and Northern Ireland, as a result of the relative scarcity of labour in the east Midlands. This represents a continuation of the dispersal of the industry on a national level which has been evident since knitwear manufacturing became a factory industry.

A recent development of considerable significance has been that of warp-knitting, using synthetic filament yarns (see below, p. 575). In addition to catering for new markets such as stretch tights for women, warp-knitted cloth has made great inroads into the traditional markets for Lancashire woven cloth. About one-third of the entire industry is in the hands of Courtaulds, and by 1968 some 80 per cent of women's lingerie and night-wear was produced by warp-knitting, and nearly one-half of the shirt-making material, with a substantial share of the output of sheeting and garment linings.

## Lace[1]

The making of lace was probably introduced into this country by refugees from Flanders, and during the seventeenth century it became an important female domestic occupation in many parts of southern and Midland England. The manufacture of lace by machinery began in an area relatively unfamiliar with hand lace making, however, for although lace was being made in Nottingham in the sixteenth century, this part of the Midlands was never one of the more important areas of hand lace making. The machine lace industry originated as an offshoot of the hosiery industry.[2] During the last three decades of the eighteenth century numerous attempts were made to adapt the stocking frame to the production of new meshes, with the result that by 1810 some 15 000 people were employed in machine lace manu-

1. See *Victoria County History, Nottinghamshire*, ii, 358–63. Also Felkin, *op. cit.*, and E. M. Rawstron, 'Some aspects of the location of hosiery and lace manufacturing in Great Britain', *East Midland Geogr.*, **9**, June, 1958, 16–28.

2. For further details, see D. M. Smith, 'The Nottingham lace industry', *Northern Universities Geogr. J.*, **1**, February 1960, 5–15.

facturing. The invention of the bobbin-net machine by Heathcote in 1809 gave further impetus to the industry, and during the next twenty years the population of Nottingham and its surrounding villages rose from 47 000 (1811) to 79 000 (1831). Then in 1834, Leavers adapted the Jacquard principle to the lace-frame, thus enabling patterns to be produced mechanically instead of being sewn in by hand. During this period much of the work was of a domestic nature, and large numbers of women and children were employed in various finishing processes and in preparing yarn for the machines. Most of the cotton yarn used came from Manchester, but the doubling was

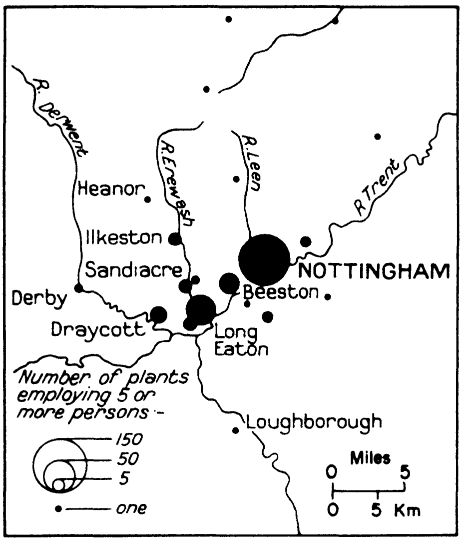



FIG. 198. The lace-making province of the Nottingham area, 1957

done in Nottingham. The lace industry, unlike the hosiery industry, was by no means entirely a domestic industry during the first half of the nineteenth century, for large factories were erected in Nottingham and Derby, and also in the West Country following Heathcote's move to Tiverton in Devon in 1814. For a brief period the West Country threatened to replace Nottingham as the main centre of the machine lace industry, but Nottingham soon reasserted its supremacy. Although the large power-driven factories were relatively rare until the second half of the nineteenth century,[1] there were many small workshops of hand-operated machines, and this, together with the (now defunct) system of hiring out machines to small manufacturers, resulted in the existence, within the industry, of a great number of small firms. This situation has persisted up to the present time, and it is common

1. In 1862, of 120 000 people employed in the lace industry, only 4000 came under the notice of the Factory Acts.

to find several small firms renting their floor space and power, within the same mill.

During the last quarter of the nineteenth century, and up to the First World War, the lace industry of the Nottingham district enjoyed a period of enormous expansion and prosperity. Since this time a marked decline has taken place as the following table shows:

*Employment in lace manufacturing*

| | 1911[1] | 1962[2] | 1966 |
|---|---|---|---|
| Nottingham and district | 35 600 | 5 400 | 6 110 |
| Rest of England and Wales | 5 400 | 1 000 | 7 200 |
| Scotland | 5 100 | 1 700 | 1 240 |
| Total | 46 100 | 8 100 | 14 550 |

[1] Census Report. [2] Ministry of Labour.

The trade has always been subject to great fluctuation in accordance with changes in fashion, but with the passing of the Victorian era and the adoption of greater simplicity in dress and furnishings the market for lace suffered a serious contraction. The lace industry has retained the remarkable concentration in the Nottingham district which has been its outstanding feature almost from its inception, an excellent example of the cumulative growth of an industry. After the city, Long Eaton is the next most important centre, but Beeston, Sandiacre, Derby and a few other places also participate (Fig. 198). With the exception of isolated mills in the West Country at Tiverton, Barnstaple, Honiton, and Chard the only other noteworthy region is Ayrshire, where lace making, principally of curtain nets, developed after about 1875 at Newmilns, Darvel, and Galston—water power sites on the Irvine river—following the decline of the local weaving industry.

## Linen

Flax-growing and the manufacture of linen have been carried on in England, Scotland, and Ireland, and since the industries in each of these countries have had little relation to one another it will be convenient to treat them separately. In each country, however, we shall find that little is known of the origin of the industry, that a considerable advancement was brought about by the influx of the foreign refugees, and that parliamentary action, in the form of duties, and historical events, such as the American Civil War, have also contributed to the development of the industry.

## England

Flax was certainly being grown in England in the twelfth century, and late in the fourteenth century a colony of linen weavers, brought by Edward III from the Netherlands, was settled in London; in the fifteenth century Norwich was the centre of the linen trade. Little expansion was possible, however, whilst the woollen industry was receiving such careful attention from the Government; no encouragement was given to linen lest it should interfere with the wool trade, and it was not until the rise of the cotton manufacture with its accompanying demand for linen warp yarn, that any great advance was made. Flax-growing and linen manufacture were domestic industries, scattered over many parts of the country, notably in south Lancashire, but the quality of the product was poor, largely owing to inadequate knowledge of, and lack of care in, the preparation of flax, and in consequence a great deal of fine linen was imported from France. The introduction of spinning machinery in 1787[1] and the development of steam power after about 1820, resulted in the concentration of the industry in the West Riding, where it reached its maximum in the 1850s. Leeds alone possessed nearly half of the 441 000 spindles in England and Wales in 1856. The increasing dominance of the wool textile industry, and the much greater development of linen and its allied fibres in Ireland and Scotland led to the decline of the Yorkshire industry; and at the present time the manufacture of linen in England is practically extinct.

## Scotland[2]

Linen was the principal export of Scotland in the sixteenth century, and its manufacture was a widespread domestic occupation. After languishing for a period, it experienced a considerable revival in the eighteenth century after the union with England, largely as the result of State encouragement. A board of trustees was set up in 1727, with funds and power to help flax growing and the linen trade—and this remained in existence for nearly a century. A little colony of French weavers from St Quentin was established at Edinburgh in 1729, and later, Irishmen and Dutchmen were brought to Scotland to teach improved methods of production and manipulation of flax and linen. At first the product was of coarse quality, and most of the export went to the American Plantations, but from the 1740s onwards finer varieties of linen cloth began to be copied from our German competitors. The domestic manufacture of the period was widespread, but with the growth and capitalisation of the industry certain divisions began to be apparent, much of the spinning being done in the northern counties (e.g. Banff, Aberdeen) whilst the weavers, although very scattered, tended to congregate in the commercial and finishing centres of the Lowlands, where,

1. First machine erected in 1787 at Darlington.
2. See Hamilton, *Industrial Revolution in Scotland*, Chapters 4–5.

as at Perth, Glasgow, Edinburgh, Dumbarton, and several places in Fifeshire, large bleaching fields were laid out. To an increasing extent, too, the eastern part of the Lowlands—Forfarshire (Angus)[1]—began to specialise in coarser types of cloth, whilst Lanarkshire and Renfrew developed the manufacture of French lawns and cambrics,[2] using imported yarn.

The phenomenal growth of the cotton industry in the western portion of the Lowlands during the last twenty years of the eighteenth century had a profound effect upon the linen trade. The manufacturers of fine French and Italian varieties of cloth in the Glasgow-Paisley region were the first to take up the new fibre, and the result was an almost complete extinction of the linen industry in that area. Just at this period, however, flax-spinning machinery was introduced, and the linen industry in the eastern counties, aided by the presence of water-power, and, after the application of steam power, of coal, entered upon a period of rapid growth, in the 1820s and 1830s. The county of Angus, with Dundee as its chief town, soon became the most important, with the adjoining county of Fife not greatly inferior. In 1836 Scotland possessed 170 flax-spinning mills (80 per cent of them in these two counties) employing over 13 000 people. The decline of domestic spinning was not paralleled by a similar contraction of the home weaving industry. Flax fibres are inelastic and were not easily worked by mechanical power, so that, although attempts were made to introduce power looms in the 1820s, their adoption was not general until after 1850, when Dundee, Coupar Angus, Brechin, Kirkcaldy, Montrose and Aberdeen became important weaving centres. The American Civil War by almost strangling the cotton trade, gave a distinct fillip to the manufacture of linen, but the prosperity was short-lived, and a steady decline set in. Possibly aided, however, by the allied jute and hemp industries, and by the facility for importing Baltic and Belgian flax (for flax cultivation in Scotland has practically ceased), the linen industry has maintained itself to a far greater extent than in England.

### Ireland[3]

Of very early origin, the manufacture of linen in Ireland was for a long period given no encouragement as being prejudicial to the wool trade. It is thus of little moment until the seventeenth century, towards the end of which legislation laid for it a permanent foundation by prohibiting the export of wool from Ireland except to Britain (lest the cheap Irish labour should undercut England's wool trade in foreign markets), and by admitting Irish flax and linen into England free of duty. Its growth was materially

1. For example, Dunfermline (Fife), long renowned for table linen.
2. As late as 1767, forty skilled craftsmen were brought from France to teach the spinning of fine yarns, and settled at Anderston.
3. See H. W. Ogden, 'The geographical basis of the Irish linen industry', *J. Manchester geog. Soc.*, **45**, 1934 35, 41 56.

aided, too, by the influx in 1685 of Huguenot refugees, who settled mainly in Protestant Ulster and in Dublin (those in Dublin being chiefly silk and poplin weavers); while the encouragement of flax-growing by Charles II and the improvement of the methods of cultivation and bleaching by the Huguenots were other contributory factors. As in Scotland, a Board of Trustees was established to assist the growing of flax and to preserve the quality of the produce by grading and marking all cloth; like the Scottish board, this continued in action for more than a century. The vast expansion of the trade during the eighteenth century[1] was achieved entirely without mechanical power, and until about 1830 the linen manufacture was a cottage industry; only in 1828 was the first flax-spinning machine erected in Belfast, and although power looms began to appear from 1850 onwards, hand-loom weavers remained an important section of the linen operatives until the First World War. Power machinery rendered certain the dominance of the Ulster region, by reason of its nearness to imported coal supplies and to the port of Belfast. Over the rest of Ireland production, except perhaps for home use, has practically ceased.

### Processes in the linen industry

Flax is by no means so simple a fibre to deal with as cotton, and it is very liable to be injured by careless treatment during the preparatory processes. The pulled flax must first be retted in water in order to remove soft tissues and gummy matter and to facilitate the separation of core and fibre. It is in this process that ignorance or carelessness on the part of the farmer may lead to much damage. The retted stalks are then scutched (beaten) to remove the woody core; the waste fibre produced thereby is called 'tow' and is used for making twine and canvas. After scutching, about 5 per cent by weight of the original flax plant remains. Before spinning, the fibre must be submitted to roughing and hackling processes—i.e. combing out short fibres (producing more tow), untangling and parallelising the fibres, and then cutting out the middle (best) part of each length. The 'line' (as distinct from tow) is combined by machinery into slivers, which are further drawn out in a drawing frame and wound on bobbins for spinning. In Scotland dry spinning is mostly practised—giving strong yarn for towelling and for weft in mixed goods. In Ireland, for finer and more even yarn, the rovings are passed through hot water before spinning. The spun yarn is doubled for use in the lace, tailoring, carpet, and fishing-net trades; and yarn for fine linen goods is bleached and boiled before being woven. The weaving process needs no comment. To a greater extent than any other textile, linen derives benefit from bleaching. Grass bleaching is still done in Ireland, away from the smoky towns, but most of the linen is bleached and finished by chemical and mechanical methods.

1. Annual export 1700: about 180–275 thousand metres (200–300 thousand yards). 1800: about 27–37 million metres (30–40 million yards).

The products of the linen industry are four in number: *Yarn*; *brown cloth* (unbleached)—canvas, duck and drills; *fully bleached*—for shirtings and sheets, damasks and cambrics; *articles* made from fully bleached cloth—sheets, handkerchiefs, table-cloths, and so on, in immense variety, plain and embroidered.

## Raw materials

Flax is no longer grown in commercial quantities in Northern Ireland, and the English and Scottish crops being negligible, supplies of raw flax, tow and yarn are imported.

*Imports of flax and linen yarn* (thousand cwt)

| VARIETY OF PRODUCT | 1913 | AVERAGE 1921–25 | AVERAGE 1926–30 | 1931 | 1935 | AVERAGE 1951–55 | AVERAGE 1956–60 | 1966 METRIC TONS | 1966 '000 CWT |
|---|---|---|---|---|---|---|---|---|---|
| Raw flax | 1 686 | 564 | 708 | 579 | 679 | 572 | 638 | 21 900 | 432 |
| Tow or codilla | 364 | 140 | 132 | 286 | 444 | 191 | 238 | 14 225 | 280 |
| Flax yarn | 248 | 89 | 143 | 138 | 20 | 31 | 23 | 2 300 | 46 |

*Ports importing flax and linen yarn* (thousand cwt)

| TOWN | 1913 | AVERAGE 1927–30 | 1931 | 1935 | 1948 | 1955 | AVERAGE 1956–60 | 1966 METRIC TONS | 1966 '000 CWT |
|---|---|---|---|---|---|---|---|---|---|
| Belfast | 1 363 | 492 | 696 | 681 | 312 | 435 | 520 | 17 000 | 338 |
| Dundee | 451 | 182 | 113 | 288 | 100 | 240 | | 10 700 | 211 |
| Leith | 266 | 149 | 102 | 80 | | | | | |
| Aberdeen | 106 | 45 | 12 | 1 | | 69 | 440 | | – |
| Glasgow | 33 | 28 | 15 | 16 | 20 | | | 7 400 | 146 |
| London | 70 | 16 | 38 | 8 | | | | | – |

*Flax production of Northern Ireland* (thousand cwt)

| 1913 | AVERAGE 1926–30 | 1931 | 1939 | 1948 | AVERAGE 1951–55 | AVERAGE 1956–60 | 1962 |
|---|---|---|---|---|---|---|---|
| 253 | 116 | 28 | 90 | 80 | 61 | | Nil |

*Imports of flax, tow and linen yarn by countries* (thousand cwt)

| COUNTRY | 1913 | AVERAGE 1921–25 | AVERAGE 1926–30 | 1931 | 1935 | AVERAGE 1951–55 | AVERAGE 1956–60 | 1962[2] METRIC TONS | 1962[2] '000 CWT |
|---|---|---|---|---|---|---|---|---|---|
| USSR[1] | 1 583 | 74 | 34 | 120 | 458 | | | | |
| Estonia | | 79 | 67 | 6 | 66 | 21 | 292 | 8 100 | 160 |
| Latvia | | 168 | 319 | 442 | 168 | | | | |
| Lithuania | | 12 | 22 | 2 | 19 | | | | |
| Netherlands | 33 | 40 | 46 | 17 | 64 | 94 | 79 | 1 400 | 28 |
| Belgium | 517 | 259 | 378 | 340 | 343 | 551 | 415 | 16 200 | 319 |
| France | 42 | 17 | 38 | 36 | 5 | 32 | 16 | 2 400 | 48 |

[1] Russia prior to 1921. [2] Includes Poland 38.

Before 1914 Russia supplied the bulk of the requirements, but between the Revolution and 1932 only a very small proportion came from the USSR. This proportion notably increased during the 1930s, declined to nothing during the Second World War, but has since partly recovered. The chief flax-growing area of old Russia lay in the northwest, and in the erstwhile republics of Latvia, Estonia, and Lithuania. The main source now is Belgium, and the adjacent parts of France and Holland. From Belgium also most of the imported yarn is derived.

## The linen industry today

The United Kingdom possesses about one-third of the world's flax spindles, and Ulster is the greatest linen manufacturing region of all. Belfast is the hub of that industrial area, and three-quarters of the mills are within thirty miles of the city. Belfast dominates the linen industry to an even greater extent than Manchester does the cotton industry, for it is the chief manufacturing centre as well as being the commercial focus and port. Other important centres are Lurgan, Banbridge, Portadown, Ballymena and Lisburn, but many of the small towns are associated in one way or another with the industry (Fig. 199). Research is carried on at Lambeg. There is some separation of spinning and weaving, many firms confining themselves to one branch only, but the division is not so marked, either economically or geographically, as was the case of the Lancashire cotton industry. Nearly all the cloth woven in Northern Ireland is finished there and a considerable section of the industry is engaged in making up and embroidering sheets, pillow-cases, handkerchiefs, etc. The Irish linen industry suffered considerably from the competition of more cheaply produced yet artistically finished cotton goods, and from the decline in the demand for linen blouses and embroidered work; but much was done after 1918[1] to improve the

1. The Linen Industry Research Association was formed just after the First World War. It had Government backing and included all the principal firms in its membership.

quality of the Ulster flax by scientific approach to the problems of cultivation and retting. Many firms, moreover, are now concerned with the spinning and weaving of manmade fibres (see p. 576) as well as flax.[1]

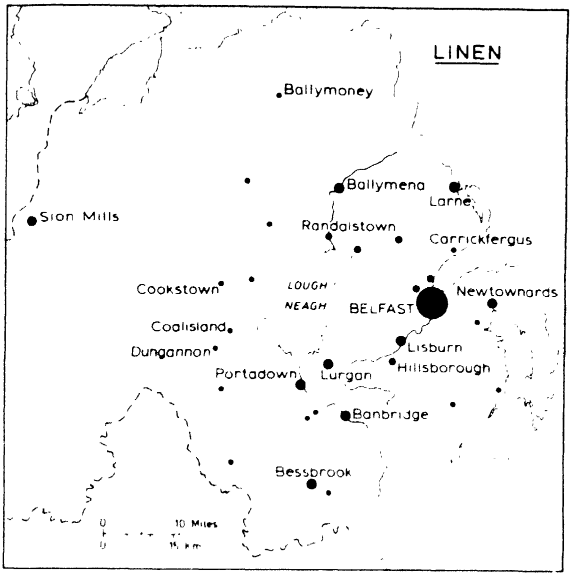



FIG. 199. The linen industry of Northern Ireland
Symbols roughly proportional to the importance of the various centres as measured by numbers employed in the 1950s

Whereas Ireland has always been famous for its fine quality linen, eastern Scotland has for a long period been associated with the coarser types of product. This is partly, no doubt, due to the remarkable development of the manufacture of the coarser fibres, jute and hemp, in that region. Of a number of towns in the counties of Angus, Perth, and Fife, devoted to the linen industry, the chief are Kirkcaldy, Dunfermline (famous for its damasks), Dundee, Forfar, and Brechin (Fig. 200). Most of the linen yarn is obtained from Belfast.

The linen industry depends primarily upon the export market. Formerly only about 20–30 per cent of its produce was retained in the United Kingdom; about a third of the output is still exported. Unlike cotton its chief market is North America, and it is thus an important dollar earner. The United States has for many years taken one-third of the total exports, and Commonwealth countries are high on the list. West Germany and Italy are the chief customers for yarn.

1. See *Belfast in its Regional Setting* (British Association for the Advancement of Science, Handbook, 1952, p. 151).

*Export of linen yarn and manufactures by countries* (thousands of £s)

| COUNTRY | 1913 | AVERAGE 1921–25 | 1931 | 1935 | 1950 | 1960 | 1966 |
|---|---|---|---|---|---|---|---|
| China | 38 | 85 | 293 | 343 | 7 | — | 333 |
| USA | 3 962 | 5 906 | 2 496 | 2 142 | 6 559 | 5 353 | 4 457 |
| Brazil | 212 | 295 | 97 | 208 | 1 171 | — | .. |
| Argentina | 334 | 340 | 91 | 134 | 162 | — | .. |
| South Africa | 145 | 224 | 136 | 349 | 588 | . | 268 |
| India | 254 | 320 | 163 | 147 | 76 | — | — |
| Canada | 690 | 911 | 565 | 617 | 1 070 | 1 019 | 498 |
| Other countries | 3 829 | 4 359 | 2 084 | 3 252 | 10 110 | 10 181 | 5 760 |
| Total | 9 464 | 12 438 | 5 925 | 7 192 | 19 741 | 16 553 | 11 316 |

In 1960 other countries included Australia (1355), West Germany (883), and Italy (567); in 1966 they included Sweden (588), Italy (513), Hong Kong (476), Australia (421), West Germany (418).

## Hemp and Jute

The term hemp is applied very loosely to a number of fibres. Soft, or European, hemp is obtained from the stalk of the hemp plant, like flax, but large quantities of hard fibres, also known as hemp, are obtained from the leaves of subtropical or tropical plants—as manila hemp from the Philippines, phormium from New Zealand, sunn hemp from India, and sisal from West and East Africa and Mexico. The hemp fibres can be used for the coarser varieties of 'linen', and in addition are much in demand for the manufacture of rope and twine, canvas, and sacking. All the hemp used in Britain has to be imported. The hemp-using industries are widespread, but

*Import of raw jute* (thousand cwt)

| | 1913 | AVERAGE 1921–25 | AVERAGE 1926–30 | 1931 | 1935 | 1950 | 1966 METRIC TONS | 1966 '000 CWT |
|---|---|---|---|---|---|---|---|---|
| Total import | 7016 | 3095 | 3749 | 2955 | 3635 | 2253 | 89 100 | 1755 |
| From India } From Pakistan } | 6951 | 3054 | 3628 | 2894 | 3634 | 86<br>2166 | 87 400 | 1720 |

*Ports importing raw jute* (thousand cwt)

| TOWN | 1913 | 1931 | 1935 | 1948 | 1960 | 1967 METRIC TONS | 1967 '000 CWT |
|---|---|---|---|---|---|---|---|
| London | 2564 | 488 | 668 | 300 | . | | ... |
| Dundee | 4350 | 2424 | 2742 | 1520 | 2430 | 113 300 | 2230 |

tend to be concentrated (*a*) in the linen-manufacturing areas of north-eastern Ireland and eastern Scotland; (*b*) in the textile districts of south Lancashire and the West Riding, and (*c*) at the principal ports where there is a constant demand for rope and sacking. Belfast has one of the largest rope works in the world.

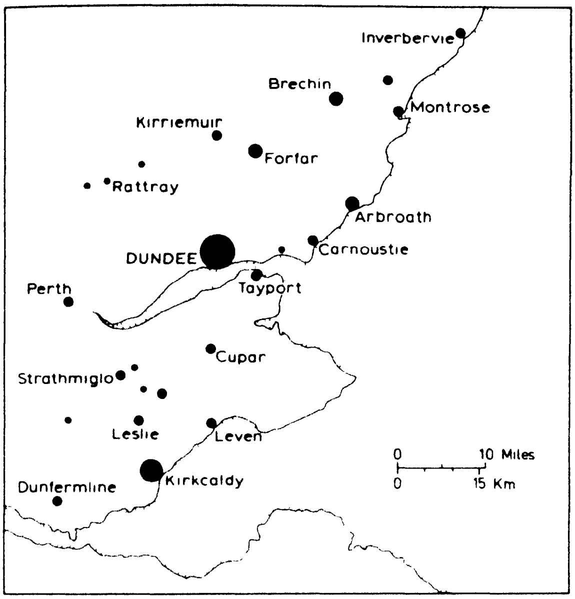



FIG. 200. The east Scottish jute hemp linen province

Symbols roughly proportional to the importance of the various centres as measured by numbers employed in the 1950s

*Jute* is a coarse fibre which will not bleach but dyes well, and although strong, perishes on exposure. It owes its lead among the minor textile fibres to its cheapness, which is due partly to the great production per acre and partly to the ease with which it can be prepared, spun, and woven by modern methods. The jute industry in Britain grew out of the flax and hemp manufacture of the Dundee region, whither Indian jute began to make its way in the 1830s.[1] Its progress at first was slow, owing to the difficulty of manipulating the fibre and of adapting the flax machinery to its use, but in the 1850s the industry became so profitable that most of the Dundee spinners and weavers changed over from flax to jute and the new fibre became the principal material for sackcloth and hessian, and was used with hemp to produce coarse sheeting. Another important use found for it was in the

1. W. H. K. Turner, 'The evolution of the pattern of the textile industry within Dundee', *Trans. Inst. Br. Geogr.*, **18**, 1952, 107–19; also *Dundee and District*, British Association for the Advancement of Science, Handbook, 1968, 162–72.

manufacture of carpets and linoleum; the town of Kirkcaldy has become the chief centre in Britain for floorcloth manufacture. A very large propor-

*Export of jute manufactures by countries (including yarn but excluding cordage, etc.)* (thousands of £s)

| COUNTRY | 1913 | AVERAGE 1921–25 | AVERAGE 1926–30 | 1931 | 1950 | 1960 | 1966 |
|---|---|---|---|---|---|---|---|
| Netherlands | 148 | 154 | 289 | 123 | * | 230 | 23 |
| Belgium | 104 | 72 | 174 | 44 | * | * | * |
| USA | 1653 | 1891 | 1525 | 499 | 508 | 930 | 209 |
| Brazil | 299 | 322 | 388 | 214 | * | * | * |
| Argentina | 673 | 549 | 371 | 73 | * | * | * |
| South Africa | 85 | 147 | 146 | 74 | 132 | 152 | * |
| Canada | 487 | 412 | 464 | 150 | * | 459 | 185 |
| Other countries | 1890 | 1964 | 2001 | 1059 | * | * | 1251[1] |
| Total | 5339 | 5511 | 5358 | 2040 | 4314 | 4174 | 1668 |

* Not available.   [1] Includes Denmark 378, Australia 236.

tion of the jute industry is still centred at Dundee, very few other places, except one or two nearby towns (e.g. Tayport, Forfar and Kirriemuir) and a few of the principal ports, having adopted it. Indeed, in 1968 'over 90 per cent of the jute spindles in the United Kingdom and two-thirds of the weaving machinery were located within the boundaries of the city of Dundee, and the remainder were to be found in towns within a radius of twenty miles of Dundee; the total number employed in jute was about 16 500'.[1] The tables above illustrate the jute trade.

## Silk

Judged by the length and fascination of its history,[2] the silk industry deserves a chapter to itself. The late eighteenth and early nineteenth centuries were the most prosperous days of the industry, and although there have been occasional increases in demand for silk in the twentieth century, developments in artificial fibres since 1945 have largely extinguished the market for the more expensive yarn. Silk, like wool, has been worked by domestic labour in many parts of Britain, and many of the early centres of the industry were influenced by the pre-existing wool-working towns. In subsequent periods other textile industries have exercised an attraction,

1. *Dundee and District*, British Association for the Advancement of Science, Handbook, 1968, p. 342.
2. See Sir F. Warner, *Silk Industry of the United Kingdom*, London, 1921 – a very detailed treatment.

such as hosiery, flax, worsted, and cotton, by providing a market for yarn or by using closely allied machinery. Except in Yorkshire, the major centre in the nineteenth century for fabrics using a mixture of different yarns, the mechanised silk industry has tended to occupy sites peripheral to the major textile regions, for example in southeast Cheshire and, along with flax, between the Cotswold and Devonshire wool producing districts.

Although earlier records exist, the real beginning of the silk industry dates from the sixteenth and seventeenth centuries, when skilled Flemish and French craftsmen were seeking refuge in Britain from persecution on the continent. In the sixteenth century Flemish weavers were making bombazines in Norwich and Colchester (early centres of the worsted industry). The influx of Huguenots, in and after 1685, brought further skill to Britain, and refugees were found in many towns, particularly in the southeast where they landed and in the West Country. A colony of considerable size was established in Spitalfields,[1] in the east end of London, which soon became the dominant centre of the industry. By 1700 the silk industry was one of Britain's most flourishing trades and manufacturing was commenced in many likely and unlikely towns all over the country, sometimes by refugees but often by enterprising natives. Protection of the industry by heavy duties, and later the prohibition of imports helped the industry to expand in various parts of the country in the eighteenth century, raw silk being chiefly obtained from Italy, China, and India.[2]

The introduction of mechanical silk throwing to this country from Italy by John Lombe in 1717 paved the way for the establishment of large mills, although it was nearly a century before powered weaving of this delicate fibre was possible. In Derby where Lombe established his mill, silk throwing developed to supply the growing hosiery industry, and by 1830 silk ribbon manufacture had been added to the throwing and silk hosiery industries as the staple trades of the town. Macclesfield, which had made silk buttons in the sixteenth century and had supplied Spitalfields with yarn even before mechanisation, developed into the major mill town for silk in the early nineteenth century. Norwich reached the height of its prosperity between 1740 and 1760, while in Suffolk and Essex, silk weaving providentially replaced the declining worsted industry, particularly in Sudbury. Coventry grew as the major ribbon producer from 1700 and many West Country towns took up the trade. Dublin had a flourishing silk industry mainly producing poplins, in the late eighteenth century, developed by French immigrants, and at Paisley, where silk gauzes began to be made around 1760, no less than 10 000 people were employed in the 1780s, before the coming of cotton almost ruined the trade.

1. Spitalfields already had a wool-weaving industry, carried on mainly by Nonconformists – two very good reasons for the settling of the dissenters there. About 15 000 foreigners settled in London and its eastern suburbs in 1685–86.

2. 1713–65, heavy duties on imported silk manufactures; 1765–1826, total prohibition of import; 1826–60, tariff of 15 per cent *ad valorem*; 1860, abolition of all duty.

Water power had an important locational effect in an industry which until then had had few physical restraints on its distribution. Derby was developed in preference to Nottingham; Leek, although in Macclesfield's sphere as a domestic producer, had no power resources until steam was introduced, and hand-weaving centres such as Spitalfields and Coventry established water powered throwing mills in the Chilterns and north Cotswolds.

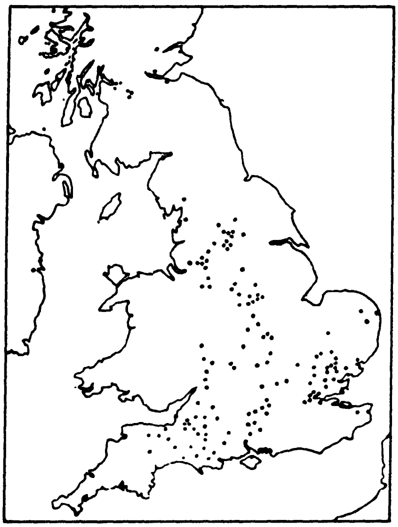


FIG. 201. Map showing all localities where the silk industry has been carried on in Britain

Notice the concentration in (1) London and the Eastern Counties; (2) the West Country; (3) the Midlands, including the West Pennines; (4) the Lancashire-Yorkshire textile regions and (5) the Scottish Lowlands.

The greatest period of the silk industry was the first half of the nineteenth century. Macclesfield was at the heart of the major silk producing area though many towns in East Anglia and the West Country possessed silk mills, and hand-weaving occupied large numbers in Spitalfields, Coventry, and Manchester. In Spitalfields, however, there was a rapid decline after the widespread application of power in the provinces, owing mainly to the higher wage costs. And in Lancashire, hand-loom weaving—introduced when mechanised cotton weaving displaced many workers—also declined, while the large powered branch of the silk industry in Lancashire shrank before further advances by cotton.

The introduction of machinery for spinning 'waste' silk (short fibres) in the 1830s brought the industry to the West Riding, where the Leeds flax industry provided closely allied machinery and where spun silk was widely used for admixture with alpaca and fine worsteds. Fine silk dyeing de-

veloped at Macclesfield and Leek, based on the pure water supply of the Pennine streams, though at Congleton, the other major silk town of the southwest Pennines, dyeing never developed as the town supply of water on which the dyers would have to depend was too hard.[1]

After the abolition of the duties in 1860, the English industry shrank before competition and 'dumping' of cheap French silks, although some products, particularly spun silks, survived the onslaught. By contrast, the Coventry ribbon trade was ruined literally overnight. By the beginning of the twentieth century, the West Riding and Macclesfield areas accounted for over half of the total employment in the industry, with a further 12 per cent in East Anglia, while in centres like Derby, Spitalfields, and the West Country towns, the industry had practically ceased to exist. The 130 000 employees of 1851 were reduced to 39 000 by 1901, though part of this decline can be explained by greater productivity following large-scale factory production.

In the twentieth century, silk was the first textile to give way to artificial fibres, both because of its expense and because of the greater suitability of its machinery to handling continuous filament yarns. The Courtaulds, an immigrant family of silk manufacturers, were the first to develop artificial fibres in England and have remained in the forefront ever since. In those towns of the southwest Pennines and Yorkshire most closely associated with silk, manmade fibres have gradually replaced silk in both throwing and weaving processes, although a little pure silk is occasionally manufactured, while East Anglia can only boast of a few hand-loom silk weavers. Since the war, hosiery and knitwear concerns have become important in the Macclesfield area and the manufacturers, though proud of their past,[2] are becoming absorbed into an amorphous clothing industry made up of large-scale concerns.

The following tables illustrate the silk trade.

*Imports of raw and semi-manufactured silk* (thousand lb)

| VARIETY | 1913 | AVERAGE 1921–25 | AVERAGE 1926–30 | 1931 | 1935 | 1950 | 1967 |
|---|---|---|---|---|---|---|---|
| Raw silk | 970 | 717 | 1290 | 1875 | 4288 | 1780 | 424 |
| Knubs and waste | 6272 | 3024 | 2789[1] | 1537 | 2544 | 260 | 283 |
| Noils | 1120 | 183 | | | | — | 5 |
| Thrown silk | 479 | 45 | 798[2] | 952 | 162 | 11 | — |
| Spun silk yarn | 575 | 682 | | | | 36 | 59 |

[1] 1926–1935. 'Cocoons and waste of all kinds'. [2] 1926–1935. 'Silk yarn'.

1. For a detailed examination of the geographical factors, see C. L. Mellowes, 'The geographical basis of the West Pennine silk industry', *J. Textile Inst.*, 1934, 376–88. A more recent work is P. D. Wilde, 'Growth, decline and locational change in the English silk industry of the nineteenth century', Ph.D. thesis, University of Keele, 1970.

2. In the current (1969) official guide to Macclesfield fifty-eight firms are listed as 'silk and associated industries', and of these fifteen are throwsters or (silk) manufacturers.

*Import of raw silk by countries* (thousand lb)

| COUNTRY | 1913 | AVERAGE 1921–25 | AVERAGE 1926–30 | 1931 | 1935 | 1950 | 1967[1] |
|---|---|---|---|---|---|---|---|
| China | 508 | 312 | 369 | 320 | 285 | 41 | 379 |
| Japan | 102 | 104 | 526 | 1208 | 3549 | 1414 | – – |
| Italy | 58 | 177 | 206 | 205 | 161 | 381 | – |
| France | 194 | 13 | 60 | 40 | 60 | | |

[1] The total of 424 includes Switzerland 25 and other countries 20 th. lb.
1000 lb = 453.6 kilogram.

*Export of silk and manufactures thereof by countries, 1913–66* (thousands of £s)

| COUNTRY | 1913 | AVERAGE 1921–25 | AVERAGE 1926–30 | 1931 | 1935 | 1966 |
|---|---|---|---|---|---|---|
| USA | 413 | 223 | 247 | 59 | 91 | 473 |
| Argentina | 86 | 102 | 59 | 32 | 104 | |
| India | 89 | 67 | 72 | 43 | 82 | |
| Australia | 147 | 335 | 348 | 202 | 120 | 53 |
| New Zealand | 29 | 83 | 60 | 41 | 31 | |
| Canada | 204 | 174 | 120 | 42 | 44 | 25 |
| France | 322 | 244 | 170 | 106 | 117 | 21 |
| Germany | 241 | 18 | 131 | 56 | 92 | 69 |
| Other countries | 627 | 883 | 895 | 456 | 441 | 155 |
| Total | 2158 | 2129 | 2102 | 1037 | 1142 | 796 |

## Manmade fibres

The use of 'artificial' fibres in the textile industry is a relatively recent development, for although much of the experimental work was accomplished between 1850 and 1900, and although the first British artificial silk was made by Courtauld's (the Braintree silk firm) at their Coventry factory in 1905, it is really only since the First World War that 'rayon' has become a textile material of serious importance, whilst the rise of the 'nylon' industry can be dated from the Second World War, and the development of polyester and acrylic fibres is even more recent. Fundamentally, manmade fibres production is a chemical industry: rayon may be described as 'regenerated' fibre, derived from organic substances such as wood pulp and cotton linters, whilst nylon and the others are 'synthetic', their raw materials being chemicals derived from coal or petroleum.

The chemical side of the industry will be dealt with in Chapter 22; suffice it here to mention that there are two varieties of rayon or regenerated fibre, viscose and acetate, the former being much the more important. A very large proportion of the cellulosic fibre production and use is in the hands of Courtauld's, whose brand names such as Vincel and Tricel are

well known. The synthetics fall into three groups: (*a*) the nylons, including Bri-nylon (made by ICI), Celon (Courtauld's) and Enkalon (made by British Enkalon); (*b*) the polyesters, including ICI's Terylene and British Enkalon's Terlenka; (*c*) the acrylics, including Courtauld's Courtelle and Monsanto's Acrilan.

The products of the chemical side of the industry may take one of two main forms: (*a*) continuous filament produced by extrusion, which can then be converted into yarn by twisting together anything from twenty to one hundred filaments; (*b*) staple fibre, consisting of similar filaments cut into short lengths corresponding to long-staple cotton or short-staple wool. Both continuous yarn and staple fibre (after spinning) can be woven on ordinary textile machinery just like cotton and wool, and as has already been noted in the chapters on wool and cotton, a great deal of admixture now goes on, to produce fabrics with new appearance, new textures and new wearing properties.

The production of manmade fibres in the United Kingdom has had a meteoric rise since the Second World War, and indeed output expanded ten times between 1956 and 1968, to nearly 545 million kilograms (1200 million lb). Since no real silk is produced in Britain these figures may be compared with an import of under quarter a million kilograms (half a million lb) of real silk.

The 1968 output included 160 million kilograms (353m lb) of viscose staple, 47 million kilograms (126m lb) of continuous filament viscose (largely for use in motor tyres), 40 million kilograms (88m lb) of continuous filament acetate and triacetate (largely for knitting and for the production of women's dress fabrics), 13 million kilograms (29m lb) of acetate staple (largely for making filter tips for cigarettes), 144 million kilograms (318m lb) of continuous filament synthetics (which go into ordinary weaving on both cotton and wool systems, and into both warp knitting and weft knitting), and 124 million kilograms (273m lb) of synthetic staple fibre (comprising roughly 60 million kilograms (130m lb) acrylics, 45 million kilograms (100m lb) polyester and the rest nylon).

Since the manmade fibre industry is part chemical and part textile, and since moreover some of the works that produce the filament also spin yarn, it is difficult to offer much in the way of generalisation as to the geographical influences on location. In a sense each installation is peculiar to itself. The earliest works was at Coventry—a development from one of Courtauld's existing silk factories—and others before the Second World War were at Spondon, near Derby (originally a cellulose factory), at Doncaster, at Wolverhampton, at Flint and Greenfield on the Flintshire coast, at Liverpool (Aintree) and at Preston.[1] Since the Second World War there has been a vast expansion, as noted above, particularly in the manufacture of

1. For an analysis of this early stage in the development of the regenerated fibres industry see H. A. Moisley, 'The rayon industry in Great Britain', *Geography*, **34**, 1949, 78–89.

synthetic fibres, and the most notable developments have been on Tees-side at Wilton (part of the great ICI chemical complex), at Grimsby (part of the general industrialisation of south Humberside), and in Northern Ireland (where government policy has attracted an international array of giant firms with American, British, German and Dutch capital to such places as Carrickfergus and Kilroot on Belfast Lough, Coleraine, Antrim, Armagh, Dungannon and Limavady). Northern Ireland, indeed, now produces one quarter of all the United Kingdom output of synthetic fibres. Outlying centres are at Pontypool and Hirwaun in the 'development area' of South Wales, at Manningtree in Essex and at Tiverton in Devon—the last two with a long history of textiles behind them.

However, the *using* of the fibres is definitely a textile industry, and as such, whether it be connected with fabrics made wholly of manmade fibres or mixed with cotton, wool, worsted or linen, it has attached itself to the pre-existing textile industries, in south Lancashire—where probably half the cloth now produced in the weaving area north of Rossendale is either wholly or in part woven with manmade fibres—in west Yorkshire (especially the worsted district), in the erstwhile silk province of Macclesfield–Leek, in the east Midlands (Nottingham, Leicester and Long Eaton), and in west Scotland (Glasgow–Paisley); some of the few remaining centres of the textile trades in East Anglia now use manmade fibres (e.g. Braintree, Sudbury) and there are several factories in the London area and in Northern Ireland.

As the following table shows, a very lucrative export trade has been built up, particularly with our European neighbours, with the Commonwealth and with the United States.

*Export of synthetic fibres and manufactures thereof, 1966* (thousands of £s)

| | |
|---|---|
| Australia | 2 457 |
| New Zealand | 3 989 |
| Canada | 868 |
| India | 218 |
| Pakistan | 104 |
| Hong Kong | 2 186 |
| Ireland | 3 042 |
| France | 346 |
| Germany | 1 525 |
| Sweden | 3 843 |
| Switzerland | 3 581 |
| South Africa | 4 392 |
| USA | 1 306 |
| Other countries | 19 457 |
| Total | 47 014 |

In concluding this three-chapter study of the textile industries, it is pertinent to call attention to Fig. 202 which shows the volume of the export trade over a period of ten years. Clearly cotton has slumped, while wool has just about held its own; in the case of manmade fibres thc home market is clearly absorbing most of the vast increase in fabric output, and only yarn exports are increasing steadily.

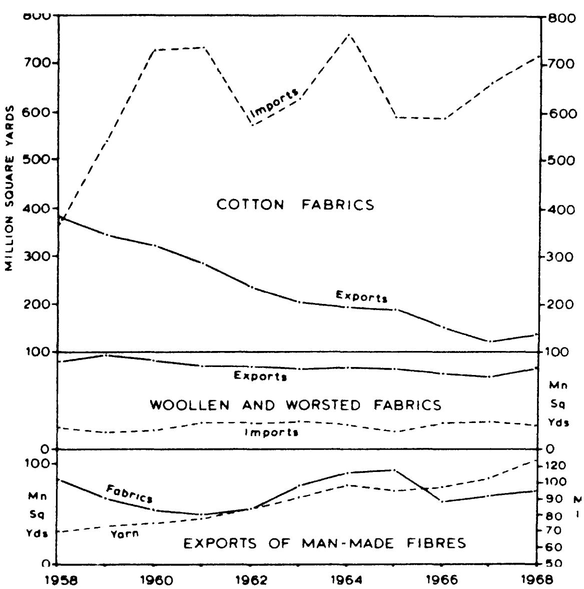



FIG. 202. Exports and imports of textile fabrics, 1958–68

# 22
# The chemical industries[1]

Lord McGowan, former Chairman of Imperial Chemical Industries, Ltd, once described the chemical industry as the most polygamous of all industries. There are few manufacturing industries today which can dispense with the services of the chemist, and the vast field now covered by the chemical industry is the natural result of cooperation between the chemist and his fellow scientists, or between the chemist and the engineer and manufacturer. The chemical industry has become the foundation on which not only British industry as a whole but also modern world industry is erected. Not only has chemistry become the servant of the older industries but in many cases the powerful rival, and in some cases the master. The synthetic products produced by the combined ingenuity of engineer and chemist not only serve to meet demands created by a high standard of living, but come increasingly into competition with substances of natural origin, or even the earlier products of the chemists themselves. Thus, synthetic nitrates are more than adequate competitors for the favours of the agriculturalist requiring nitrates for fertilising. The quantity of artificial silk and chemical fibres used in the world much exceeds the quantity of natural silk. Chromium plating has replaced nickel plating just as nickel plated goods replaced brass and bronze of earlier periods. Similarly, plastics have largely replaced metals—especially brass—and also wood, glass, leather and textiles for many purposes.

The annual turnover of the chemical industry is some £2500m, a figure only exceeded by that of the engineering industries and its growth rate in recent years has been twice that of the national economy.

## The development of the heavy chemical industry

The heavy chemical industry is in many respects the chemical industry proper, embracing as it does the manufacture of those commodities which are required in large quantities and have a variety of uses. There are really two branches—the inorganic, founded essentially on two fundamental

1. I am greatly indebted to Professors H. D. Springall and I. T. Millar of Keele University for advice leading to the rewriting of this chapter.

substances, sulphuric acid and sodium carbonate; and the organic, of much more recent large-scale development, based essentially on substances derived originally from the distillation of coal and now, increasingly, on the refining of petroleum.

The birth of the whole chemical industry took place little more than 200 years ago, and indeed at the close of the eighteenth century there was scarcely a chemical industry in this or any other country—apart from the manufacture of gunpowder, a few acids in small quantities, a few drugs, and of course large quantities of soap. The chemical industry that grew slowly during the Industrial Revolution in the late eighteenth and early nineteenth centuries largely revolved around the needs of the textile, glass and metal industries: alkalis were needed for soap and bleaching materials required by the textile trades, and in glass manufacture, and sulphuric acid was used as a sour in textile bleaching and for pickling metals. One of the first chemicals produced in quantity was sulphuric acid, made in England as early as 1720, and for upwards of a century from the 1740s the acid was produced in large reaction chambers made of sheet lead, the source of sulphur being volcanic brimstone imported from Sicily. The discovery of the value of chlorine as a bleaching agent in 1785 opened up a new avenue of alkali manufacture, and towards the close of the eighteenth century the discovery of bleaching powder, or 'chloride of lime', by Charles Tennant, a Scottish linen bleacher, led in 1797 to the foundation of a chemical works at St Rollox in Glasgow. Within a few years the manufacture of bleaching powder by passing chlorine over dried powdered lime had spread to several localities. Then in 1790 the French government awarded a prize to Nicolas Le Blanc for a method of making soda, since France, owing to wars, had found it difficult to obtain a constant supply of this commodity. His method consisted of treating common salt with sulphuric acid, thus making sodium sulphate and liberating hydrogen chloride (hydrochloric acid gas), then roasting the sodium sulphate with limestone and charcoal or coal and obtaining in this way sodium carbonate and calcium sulphide.

The growth of the Le Blanc soda process in this country was slow, largely because there were adequate supplies of sodium carbonate from burnt seaweed or kelp from Scotland and of barilla (a littoral plant of the goosefoot family) from Spain and Portugal, and the first large-scale development was introduced by James Muspratt at Liverpool in 1823 and a few years later at St Helens; these two works quickly drove natural alkali from the Mersey soap factories and laid the foundations of the great chemical industry of that area, in which both alkalis and sulphuric acid were involved. The use of soda in glass-making was perhaps part of the reason for the choice of St Helens (though the local coalfield and the St Helens Canal leading to the Mersey were also contributory factors), and the association with glass certainly favoured Tyneside as an early location (the local soap industry also providing a market), and was responsible for the setting up of works at Oldbury in the Black Country to supply the Smethwick glass factory.

The fact that salt is the primary raw material in the manufacture of soda and alkalis led to the gravitation of the industry to the vicinity of the country's major saltfield in Cheshire, and to the mid-Mersey towns of Widnes and Runcorn, the former the terminus of the St Helens Canal (for coal supplies) and the latter at the point where the River Weaver and the Trent and Mersey Canal, both passing through the saltfields, reached the Mersey.[1] But it was not long before the soda manufactory became larger and more complicated. It made soda, of course, using common salt, sulphuric acid and Buxton lime, and soon added the manufacture of its own sulphuric acid by burning sulphur or pyrites. Large quantities of hydrogen chloride were produced, which at first were allowed to escape into the atmosphere (albeit from very tall chimneys) with terrible results on the areas surrounding the chemical works, and it was not until the invention of the 'Gossage tower' that hydrochloric acid could be recovered for use in making bleaching powder—which was much in demand after 1860 for esparto grass paper-bleaching as well as in the cotton and linen industries.

In the early years of the industry, for every ton of soda made nearly two tons of alkaline waste were produced, an evil-smelling mass containing practically all the sulphur from the sulphuric acid used; and although by a process introduced in 1861 a third of the sulphur was recovered, it was not until 1882 that waste was really eliminated—and some of it still scars the landscape near Widnes and St Helens. The elimination of waste was more or less forced on the chemical manufacturers by the Alkali Act of 1863, which provided for close inspection and for heavy penalties against emitting obnoxious fumes into the atmosphere.

By 1890 the British heavy chemical industry was in the hands of forty or fifty firms whose works were situated principally on the saltfield of Cheshire and the neighbouring parts of the mid-Mersey region of Lancashire, with outlying centres on the Tyne and the Clyde and a few in the west Midlands. As soda manufacturers they were suffering from the severe competition of what is known as the ammonia-soda process for the manufacture of soda. The chemistry of the process involved in the mixing of salt, ammonia, carbon dioxide and water to form bicarbonate of soda and ammonium chloride is very simple, but it was not until the 1860s that the Solvay brothers of Belgium were successful in producing soda in quantity by this process. It was they who, in 1873, granted a licence to Brunner, Mond & Co., a combination of Brunner the administrator and Mond the energetic young chemist, to manufacture in Great Britain—at Winnington, by the river Weaver, on the edge of the Cheshire saltfield. In 1890 the British heavy chemical firms were forced into combination and formed the United Alkali Co. of Liverpool. Although the object of the combination was to facilitate, by lowering costs, the continuance of the manufacture of soda

1. The Trent and Mersey canal actually ends at Preston Brook, and the last four miles to Runcorn form the western end of the Bridgewater canal.

by the Le Blanc process, they were obliged in turn to take up the ammonia-soda process. Some idea of the progress may be gauged from the production figures: in 1863 the world's production of soda was 300 000 long tons, the price about £13 per ton; in 1903 out of an annual production of 1.8 million long tons, 1 676 000 metric tons (1 650 000 long tons) were made by the Solvay process, and the selling price was only about £4 per long ton; shortly afterwards the Le Blanc process was completely abandoned.

Meanwhile, the sulphuric acid industry was also undergoing changes, largely in the sources of its raw materials. In the late 1820s pyrites from North Wales and Ireland began to be used in Liverpool, to be later superseded by richer pyrites from Spain; whilst in the 1850s the sulphur dioxide derived from copper smelting (which, previously discharged into the atmosphere, had such disastrous effects on the landscape of the Swansea area—cf. p. 470) was first used for the recovery of sulphur. Then in 1870, the iron oxide process of removing sulphur from coal gas began to yield sulphur from the spent oxide, at gas works up and down the country. The key position of sulphuric acid in chemical technology became firmly established during the nineteenth century, and by 1900 Britain was producing one million long tons a year, one-quarter of the world's output.

The ramifications of the chemical industry became increasingly apparent in the latter half of the nineteenth century, and only a few of the highlights can be noted here. The production of *cyanides* for making textile dyes such as Prussian Blue began early in the century, and there was some use of potassium cyanide in the early electroplating industry; but the revolutionary discovery in the 1880s by MacArthur that a weak solution of potassium or sodium cyanide would extract gold from low-grade ores led to a great upsurge in demand and the setting up of works at Runcorn and Oldbury to manufacture these products. The production of *phosphorus* began in 1844, for making matches; the process involved the treatment of bone-ash with sulphuric acid and then mixing the phosphoric acid with charcoal and heating in a coal-fired retort. A works was set up at Oldbury which for long remained in a monopolistic position. The use of imported phosphate rock, and the invention of the safety match in 1855, opened up larger possibilities. Also using phosphatic material was the *fertiliser* industry. In the early nineteenth century many thousands of tons of bones were annually imported for agricultural use, and it was the German chemist Liebig who first suggested treating the bones with sulphuric acid—a suggestion that was taken up by J. B. Lawes (who had inherited the Rothamsted estate in Hertfordshire that subsequently became the famous agricultural research station). Lawes set up a works at Deptford in London in the early 1840s to make superphosphate from bones, but he soon turned to mineral phosphates, using coprolites from the Severn valley and later Norwegian apatite. New sources of phosphate rock were tapped in Belgium, the United States and North Africa, and by the 1870s there were eighty works, many of them at ports where the imported rock arrived, and many of them, remote from the

major heavy chemical industries, developing their own sulphuric acid plants.

The outbreak of war in 1914 found the chemical manufacturers of this country quite unprepared. There were government factories well equipped for the manufacture of explosives, but they were only on a small scale. Firms such as Nobel had up-to-date works (established as long ago as 1871 on the remote sand dunes of the Ayrshire coast at Ardeer), but again on a scale incommensurate with wartime needs. The two main requirements were explosives and chlorine. The latter, in the form of bleaching powder, was used in large quantities as a disinfectant on the war fronts, and later as liquid chlorine for the production of chlorine as a war gas. It was the upsurge in demand that encouraged the development of the electrolytic process of chlorine manufacture that was first introduced just before the war at Runcorn, St Helens and Winnington, and is now standard practice. As for explosives, at the beginning of the war most of our shells were filled with picric acid (trinitrophenol) as a high explosive, for TNT or trinitrotoluene had only just been adopted. The first government factories for its manufacture were set up in 1915—the toluene produced from petroleum distillation at Portishead near Bristol and nitrating plants at Oldbury and at Queens Ferry on the river Dee; and later the scarce toluene resources were conserved by mixing TNT with ammonium nitrate to produce amatol explosives.

Of necessity the explosive firms in particular and the chemical firms in general had during the war period to work together and to pool their knowledge. The way was thus paved for the formation in 1918 of Explosive Trades Ltd, afterwards known as Nobel Industries Ltd. There thus came to be four firms concerned with the chemical industries of this country: Brunner, Mond & Co., Nobel Industries, the United Alkali Co., and British Dyestuffs Corporation. The amalgamation of these came naturally in 1926 with the formation of Imperial Chemical Industries Ltd.

The main developments in the heavy chemical industry since the First World War have been, on the inorganic side, the considerable expansion of sulphuric acid production, which is now running at about 3 million tons a year, with the manufacture of superphosphates, ammonium sulphate and rayon as major consumers, and on the organic side, the development of a new dyestuffs industry, the production of new materials, such as plastics and manmade fibres, and the synthesis of pharmaceuticals and of non-soap detergents. Sulphuric acid production is widespread and is in the hands of more than fifty firms—as a result of its growth in connection with the fertiliser industry, as mentioned above. During the Second World War, with Spanish pyrites unavailable, emphasis was on the import of sulphur from Texas, and this continues. But to an increasing extent home deposits of anhydrite, on Tees-side and in west Cumberland, have been brought into use, with important plants at Billingham, near Whitehaven, and at Widnes (which uses Cumberland mineral), and about one-sixth of the total output

of sulphuric acid is now derived from anhydrite. Further changes are possible using North Sea gas.

Expansion in organic chemicals has been especially rapid since the Second World War, and has accompanied the growth of an enormous oil-refining industry (cf. p. 354). Between the wars, the heavy organic chemicals industry (commonly abbreviated to HOC) was based on fermentation alcohol, coal (as coke or calcium carbide) and coal-tar derivatives. True, in the 1930s ICI had already begun producing fuel petrol by hydrogenation of coal and of creosote oil (a coal distillation product) at Billingham on Tees-side, but this was largely in connection with their use of hydrogen on a vast scale for ammonia manufacture, and it was the shortages created by the war that prompted the further development of the process. But the relative costs of coal and oil changed in the early 1950s, and the Billingham plant was abandoned and replaced by petrochemical plant. In 1949 petroleum feedstocks provided only 6 per cent of the raw material for organic chemical manufacture, but by the mid-1960s this percentage had risen to nearly 70. The first real petrochemical works in England was set up at Spondon, near Derby, by British Celanese in 1942, to provide chemicals for rayon production (cf. p. 575); but most of the subsequent works are adjacent to oil refineries—at Stanlow and Carrington, on the Mersey, at Fawley on Southampton Water, and at Grangemouth, and more recently at Baglan Bay, near Swansea. The vast 800-hectare (2000-acre) site at Wilton on Tees-side began to be developed in 1949; here there was no refinery, but the feedstocks (mainly petroleum naphtha) were brought in by tanker. Another recent development, served in this instance by pipeline (cf. p. 354), is on Severnside, north of Bristol. By 1962 capital investment in petrochemicals had reached £200m. Indeed the chemical industry as a whole is one of the most heavily capitalised of all modern industries. The current (1969) capital of ICI is £1487m, which represents £10 700 for every one of their 139 000 employees. On Severnside ICI has invested £25m, or £30 000 per employee. And yet when the group was formed in 1926 the total capital of the four constituent companies was just under £40m. While it is right to emphasise the capital-intensive character of the heavy chemical industry, and the relatively small number of giant firms engaged in it, we should not forget that there is a vast range of other chemical industries; the Board of Trade's Census of Production in 1963 included nearly 3000 companies engaged in some form of chemical manufacture—but nearly two-thirds of them employed under one hundred workers, most in the pharmaceutical branch and the great majority in the Greater London area.

## Geographical distribution of the heavy chemical industry

Geographical factors in the distribution of the various branches of the heavy chemical industry are fairly obvious, and many of the early locational in-

fluences—including sources of salt and coal, and inland water transport—continue to be important. But developments since the Second World War have added at least one completely new factor, namely the location of oil refineries (already studied in Chapter 14).

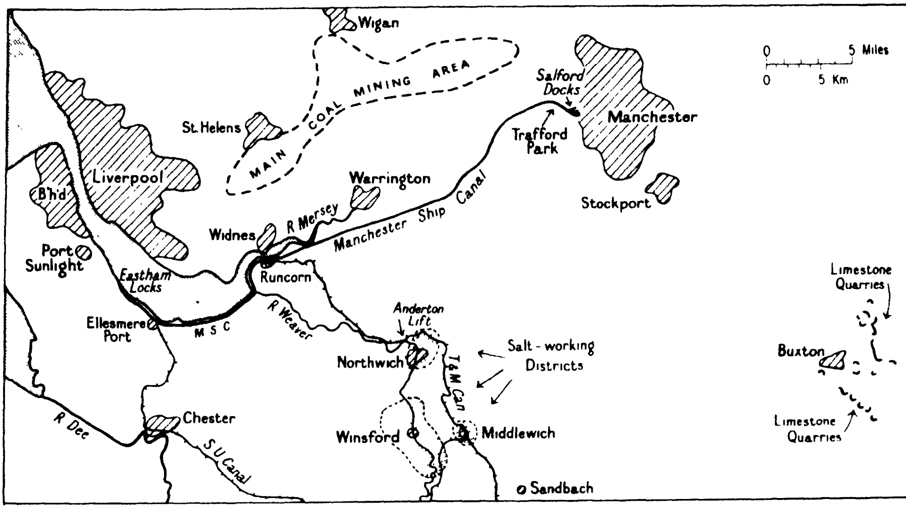



FIG. 203. The mid-Mersey chemical towns, in relation to sources of salt, coal and limestone

The Stanlow oil refinery lies just east of Ellesmere Port. Compare Fig 255.

Of the older centres, by far the most important are the mid-Mersey region and the Cheshire saltfield (Fig. 203).[1] On the saltfield is the great chemical complex at Northwich, the headquarters of the Alkali Division of ICI. The Cheshire salt industry owed much to the transport facilities provided by the Weaver Navigation and the Trent and Mersey Canal (which are linked by the Anderton lift near Northwich), and the river is still much used. The production of refined salt from pumped brine takes place mainly at Middlewich and Sandbach (the former coarse salt production at Northwich and Winsford having seriously declined), but alkali manufacture is concentrated at three large works in the vicinity of Northwich, and at Runcorn (headquarters of ICI's Mond Division) and Widnes. About half the insured population of the Northwich area is employed in the chemical industry, and about 40 per cent in Runcorn and Widnes. St Helens, despite its early start, is now scarcely a chemical town at all, being much more occupied with glass manufacture (see below, p. 590), and Warrington's connection is mainly through the soap industry. Fig. 203 expresses the space relationship of the main geographical factors involved—the location of the

1. See *A Scientific Survey of Merseyside*, British Association for the Advancement of Science, 1953, pp. 251–64.

mid-Mersey towns halfway between the sources of salt and coal (Runcorn is served with brine by pipeline from the Northwich area), with Buxton lime readily accessible by railway, and imported vegetable oils, pyrites, sulphur and other raw materials available through the port of Liverpool. The importance of Merseyside as a chemical centre has been greatly accentuated by two further developments, the piping of ethylene from the ICI's Wilton plant on Tees-side, across the Pennines to a new plant at Runcorn for the production of vinyl chloride monomer (see below, p. 594), and the advent of the great Shell oil refinery at Stanlow, near the western end of the Manchester Ship Canal, with associated petrochemical works there and at Carrington, on the Ship Canal nearer to Manchester.

PLATE 24. The ICI works at Billingham-on-Tees
The plant covers 280 hectares (700 acres) with tidewater access.

The second most important area is more closely confined, around Tees-side. A Triassic saltfield had provided the basis for the Cerebos salt industry, but the great expansion in the 1920s was due to two quite different factors. The first was the establishment of a government-sponsored nitrate factory at Billingham, in 1918 (which never in fact worked, but which provided a convenient site for Brunner, Mond & Co. to establish their subsidiary Synthetic Ammonia and Nitrates Ltd in 1920), and the second was the fortunate discovery, right underneath the works, of valuable seams of anhydrite (calcium sulphate). There could hardly have been a more appropriate occurrence, for the anhydrite was used to make sulphur dioxide (for acid manufacture), with clinker suitable for making cement as a byproduct. In the 1930s the making of oil from coal was added but the most spectacular

developments have occurred since the Second World War, with the addition of petrochemicals and the building of a whole series of new plants at Wilton concerned with heavy organic chemicals for plastics and manmade fibres (see below, p. 592). Wilton and Billingham are connected by pipeline under the river Tees. The more recent addition of oil refining on Teesside adds still further to the importance of the area as a chemical centre of world significance.[1]

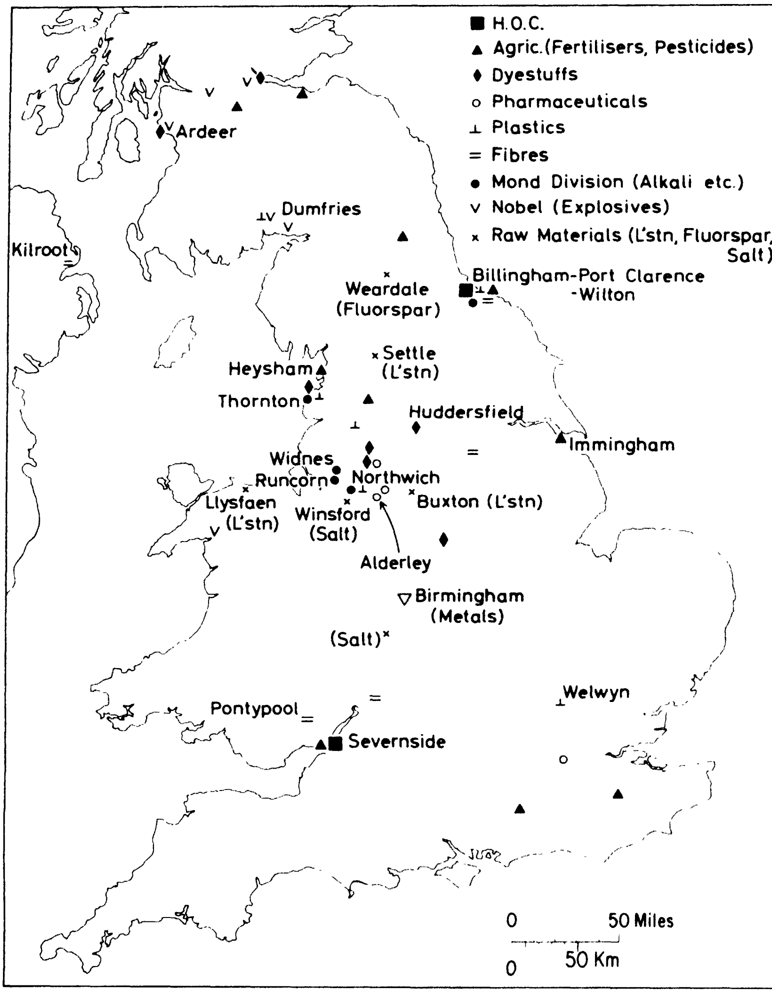



FIG. 204. The ICI 'empire'
The chemical industry is so vast and varied that it is impossible to represent it all on one map; so the principal establishments of ICI have been mapped to give some idea of the wide industrial and geographical range.

1. See P. W. B. Semmens, 'The chemical industry of Teesside and south Durham', in *Durham County and City with Teesside*. British Association for the Advancement of Science, 1970, 330–40.

In west Lancashire, the Fleetwood complex of chemical works had local brine-pumping and port facilities at the mouth of the river Wyre as its basis. In addition to alkali manufacture there are now plants for making dyestuffs and plastics—the latter fed with ethylene by a branch of the trans-Pennine pipeline from Tees-side.

On the Tyne, salt-panning was an ancient practice, and so were the making of glass and soap. Hedley's soap works was founded in 1837, and it remains a major producer of soaps and detergents. In the 1860s Tyneside was producing half the total Le Blanc alkali made in the country, but the industry declined with the introduction of the Solvay process. Sulphuric acid is made at Blaydon, and at Prudhoe-on-Tyne a wartime ammonia plant remains an important producer of sulphate of ammonia.

The association of the west Midlands with the chemical industries arises largely from the metallurgical trades and glass manufacture (see below, p. 590) and Oldbury is a good example of the tendency in the chemical industry to add new processes to existing works.

In Scotland the chemical industries grew up essentially as the servants of other industries, beginning with bleaching materials for textiles and continuing with dyestuffs, paints and fertilisers—in the vicinity of Glasgow, Grangemouth and Edinburgh. The explosives works at Ardeer now makes many other chemical products as well, whilst a great petrochemical industry has grown up at Grangemouth.

A recent addition to the heavy chemical map is Severnside, fed with raw materials through the port of Avonmouth and by pipeline from Fawley. ICI established themselves here on a 400-hectare (1000-acre) site in 1957, to make heavy organic chemicals and fertilisers; other chemical industries in the same area include the fertiliser works of Fisons, a carbon-black factory and of course the numerous chemical byproducts of the Avonmouth zinc smelting plant.

As a commentary on the above, Fig. 204 shows the location of the major chemical plants operated by ICI. Of course this does not represent the entire chemical industry, and some of the great petrochemical localities—such as Fawley, Stanlow and Swansea—are missing, as are some of the manmade fibres and fertiliser plants. But on the whole it gives a reasonably good representation of the widespread distribution, and of the concentration, of the chemical industries.

There is one characteristic of the chemical industry that differentiates it from all others; only the iron and steel industries show anything comparable. It is the extent to which the various branches are interdependent; the finished products of one branch are the raw materials of another. Thus the ICI's Mond Division in Cheshire and Merseyside supplies alkalis and other chemicals to the plastics, dyestuffs, metal and pharmaceutical divisions, the HOC Division on Tees-side and Severnside supplies a multitude of different products for fertilisers, insecticides, plastics, paints, dyestuffs, synthetic fibres, pharmaceuticals, explosives, and so on. In fact, 40 per cent of HOC's

output is sold to other sections of ICI. The importance of mass-transport media for these products—pipelines, liner-trains and fleets of road tankers—is considerable.

It remains to add the following tables showing employment in the chemical industry at different dates, and to deal in more detail with some particular branches of the industry.

*Employment in chemical industries, 1948, 1961* (thousands)

| INDUSTRY | EMPLOYMENT 1948 | EMPLOYMENT 1961 | CHIEF REGIONS[1] APPROXIMATE PERCENTAGE OF TOTAL |
|---|---|---|---|
| General Chemicals | 100 | 200 | NW 31; N. 21; London and SE 15. |
| Explosives and fireworks | 25 | 33 | Scot. 36; Wales 16; NW 16. |
| Soap, candles, and glycerine | 21 | 45 | NW 50; London and SE 15. |
| Dyes and dyestuffs | 17 | 20 | Yorks. 45 |
| Drugs and pharmaceuticals | 47 | 73 | London and SE 39; N. Mid. 15; NW 15. |
| Toilet preps. and perfumery | 9 | | London and SE 80. |
| Fertilisers and insecticides | 15 | | Scot. 20; London and SE 14; Yorks. 13; N. 13. |
| Paint and varnish | 33 | 49 | London and SE 35; NW 15; Yorks. 9. |
| Plastics materials | | 33 | |

[1] Ministry of Labour Regions.

*Employment in chemical industries, 1966*

| REGION[1] | THOUSANDS | REGION | THOUSANDS |
|---|---|---|---|
| North | 55 | Wales | 26 |
| Yorks and Humberside | 46 | W. Midlands | 32 |
| E. Midlands | 20 | Northwest | 120 |
| E. Anglia | 10 | Scotland | 34 |
| Southeast | 170 | N. Ireland | 3 |
| Southwest | 12 | | |
| | | Total | 527 |

[1] Ministry of Labour's new regions. The former N. Midlands is now called East Midlands; Yorks (W. and E. Ridings) is now called Yorkshire and Humberside. London is included in Southeast.

## The metallurgical industry

There is a close association between non-ferrous metal smelting and refining and the chemical industries, for chemicals are used in metal processing and numerous chemical byproducts are obtained. Thus it was Mond, of Brunner, Mond & Company, who discovered with a collaborator a process

for the extraction of pure nickel and floated the Mond Nickel Co. whose large works are at Clydach, near Swansea (cf. p. 484). The chemical by-products of aluminium, lead and zinc smelting have already been referred to (pp. 477, 478–9). Since the Second World War the development of the use of the rarer metals in the electrical industries, in alloy steel making and for lightweight and special-purpose alloys has widened the range of contact between chemical and metallurgical industries, and new developments are frequent. In fact the processing of these metals is for the most part done by the chemical industry and not by firms whose main interest is in metals. Magnesium, molybdenum, tantalum, titanium, tungsten and zirconium are examples. The extraction of magnesia from sea-water at Hartlepool is mainly for refractory products rather than metal. Metallic tantalum, however, has found a use in the rayon industry: it is used for the spinnerettes in the viscose process (see p. 591). Titanium, being highly resistant to corrosion, whilst of high strength and low density, is being developed for use in ships and aircraft, and especially for long-range rockets and spacecraft; it is also used as a white pigment. The industry is based on imported ilmenite, and is a major consumer of sulphuric acid; it is located within the great chemical complexes of Tees-side and south Humberside, and at Swansea. The oxides of some of these rare metals – many of the group referred to by chemists as the 'transition metals' – are used in catalytic reactions, e.g. in the production of synthetic ammonia and in petroleum cracking.

The chemical metallurgical industries are fairly widespread, but there is a notable grouping in the Birmingham area.

## Glass

The manufacture of glass is essentially a chemical process. All types of glass are made by heating in a furnace, silica (which is usually obtained in the form of sand) with soda and lime and the oxides of other metals such as magnesium, aluminium, boron or lead, according to the type of glass required – e.g. a large proportion of borax is used for Pyrex heat-resisting (i.e. low-expansion) glass. The mixtures are very complex; ordinary bottle glass contains no less than twelve chemical elements. Plate glass is rolled in continuous sheets while soft; glass tubing is drawn out; glass bottles are cast in moulds or are blown. The modern float process for plate glass uses a bed of molten tin. The main requirements of the glass industry are thus a suitable supply of fuel, sand, and chemicals, chiefly soda, lime, magnesia, and borax from the heavy chemical industry. For the finer types of glass, including colourless glass bottles, the purest white sand, free from coloured impurities, must be used. Such sand comes from the superficial Shirdley Hill Sands of southwest Lancashire and from occasional pockets in the Lower Greensand formation—as at King's Lynn, Leighton Buzzard, and Redhill—or is imported from Belgium or elsewhere. A new source of high quality sand was discovered during the Second World War at Lochaline in western Scotland.

For coloured bottles, less pure raw material is needed, and several other geological formations, as well as those named above, contribute supplies.

The glass industry in 1963 gave employment to over 72 000 people, of whom more than a third were concerned with bottle-making. The London area, by reason of its huge market for milk and beer bottles, and easy access to Lower Greensand and imported sand supplies, has a very large bottle-making industry, and other centres are Doncaster and St Helens. The latter town is also the chief in the country for glass-making other than bottles. The geographical influences here look deceptively simple—Shirdley Hill Sands and coal almost on the spot and the great mid-Mersey chemical industry only a few miles away. But, in fact, the industry was located here before the Shirdley Hill Sand was 'discovered'; this local sand supply simply confirmed the location and strengthened it. Interesting, if less obvious, locations are Stourbridge, on the edge of the Black Country (where the glass industry was started by foreign refugees several hundred years ago and was based on local fireclay, from which the crucibles, used in large numbers, were made), Smethwick, chief British centre for the making of lighthouse lanterns, and Sunderland, home of heat-resisting glass.

## Dyestuffs

The rise of the textile industries in the early nineteenth century did not generate a corresponding development in the making of synthetic dyestuffs, for the organic chemistry of the natural dyestuffs—alizarin from madder, indigo from woad and *indigofera* spp., and certain traditional dyewoods—was not understood. It was in 1856 that W. H. Perkin discovered that mauve could be produced from materials derived from coal tar, and other synthetic dyestuffs based on tar products followed rapidly. But the industry that he founded in England did not flourish, and it was left to Germany—with the help of imported British raw materials—to develop commercial dyestuff production on a large scale after the 1870s. The outbreak of war in 1914 found the British textile industries—despite the existence of two German dyestuffs firms that had set themselves up on Merseyside—quite unable to dye the uniforms that they were called upon to produce! After the war development was rapid; a works was set up at Grangemouth in 1919, and the British Dyestuffs Corporation amalgamated a number of interests in 1924, only itself to be absorbed into ICI in 1926. Thus the dyestuffs industry became inseparably bound up with the heavy organic chemicals industry, and by the outbreak of the Second World War in 1939 nearly 95 per cent of British requirements were home produced.

The dyestuffs industry was presented with a whole series of new problems by the advent of manmade fibres, which do not absorb dyes as cotton and wool do. The result has been the development of many new products and techniques, such as the impregnation of nylon and acrylic fibres with anthraquinone dyes at elevated temperatures.

The chief raw materials of the dyestuffs industry are a small group of aromatic hydrocarbons, including benzene, toluene, naphthalene and anthracene, all derived from coaltar distillation, or in some cases from petroleum refining. Naturally enough, the bulk of the output comes from the north of England, where the combination of coalfields and textile industries on both sides of the Pennines, with chemical industries and more recently oil refineries on both coasts, provides an obvious geographical control. Apart from the Tees-side chemical complex, the major centres are at Ellesmere Port, Manchester and Huddersfield, whilst in central Scotland, with a similar geographical basis, there are dyestuffs works at Grangemouth and Ardeer.

## Manmade fibres

There is an unexpectedly close connection between explosives and certain types of what used to be known as 'artificial silk', but are now generally referred to as regenerated 'manmade fibres'; for both involve the use of cellulose, which is the main constituent of dry vegetable matter, and thus forms the bulk of wood, cotton, linen and many other vegetable products. Thus, if cotton rags are treated with caustic soda, washed, bleached and dried the contaminants are removed and cellulose is the result. If the cellulose is treated with a mixture of sulphuric and nitric acid, nitrocelluloses are formed, which are in general highly inflammable or explosive substances. Gun-cotton is a nitrocellulose, and cordite and other explosives are closely associated. The principle of making artificial silk is to treat wood pulp or some other material containing cellulose with caustic soda and then with carbon bisulphide; a yellow viscous liquid is obtained which when extruded into a suitable precipitating bath of acid yields tough fibres, from which the sulphur is removed in a further process, the end product being a thread of almost as great a fineness as that spun naturally by the silkworm. This is the substance now known under the formerly patent name of *viscose* (cellulose xanthate, 1892); it was originally used for lamp filaments, but in 1905 the silk firm of Courtaulds began making it for use as a silk substitute fibre at their Coventry works. An alternative material is *cellulose acetate*, first developed in France about 1910 for photographic film (to replace the highly inflammable nitrocellulose) and made in Britain during the First World War for coating aeroplane wings and making plastic windows. The cellulose is treated with acetic acid (itself made from a byproduct of petroleum refining). A factory was set up at Spondon, near Derby, in 1916, and when the demand for its products came to an end with the cessation of hostilities it used the materials to produce the fibre known as 'Celanese'. The subsequent development of rayon, as these two cellulose-based forms of manmade fibre came to be known, has been dealt with in Chapter 21. Suffice it here to say that the location of the chemical side of the industry is in part more or less fortuitous, though access to vast quantities of water and suitable

means of effluent disposal were important siting factors—as at Greenfield on the Flintshire coast, for example.[1]

The other manmade fibres—the 'synthetics'—are of more recent development, and like the plastics, are products of polymer chemistry, a branch that represents what is probably a greater technological revolution than anything since the development of textile machinery and the steam engine in the eighteenth century. Like the plastics, too, their raw materials are largely derived from coal, or more recently from petroleum refining. Indeed, many of the new products, such as nylon and polypropylene, can be used both as plastics and as fibre. It is perhaps not surprising that many of the early developments in macromolecular chemistry took place in the USA, which had a huge oil-refining industry, and in Germany, which with its drive for self-sufficiency was developing artificial rubber and other synthetic materials. Many of the later developments, however, are British, and have become possible by reason of the great postwar expansion of oil-refining and the petrochemical industries (cf. Chapter 14).

*Nylon* was the first, a purely American development (1937), for which ICI acquired manufacturing rights in 1940. Nylon is a 'condensation polymer' (produced by the condensation of hexamethylene diamine and adipic acid). It was much used during the Second World War for parachutes, glider tow-ropes, and aeroplane tyre cord—produced by British Nylon Spinners Ltd, a firm set up jointly by ICI and the textile firm of Courtaulds; it was also used as a plastic in the wartime engineering industry. After the war, in 1949, production of fibre for the ordinary textile industry began at Wilton on Tees-side, from which it was sent to Pontypool for spinning. Later developments, in the 1960s, have been the establishment of plants at Antrim in Northern Ireland by British Enkalon (an Anglo-Dutch firm) and at Cumnock in Ayrshire by the American Monsanto Company's subsidiary Chemstrand (now Monsanto Textiles Ltd). Some nylon is employed as a plastic rather than as a textile fibre—for brush bristles and fishing lines.

*Terylene* (polyethylene terephthalate, commonly known as polyester) developed out of British research done during the war (actually in the laboratories of the Calico Printers' Association). The raw materials are xylenes derived from petroleum refining. ICI acquired the British rights, and Du Pont for the United States, and full-scale production of Dacron began in USA in 1953, and of Terylene at the vast new ICI plant at Wilton in 1955; a further ICI development took place at Kilroot near Belfast in 1963. British Enkalon at Antrim produces a similar fibre known as Terlenka, whilst the German firm of Hoechst at Limavady produces Trevira.

*Acrylic fibres.* Vinyl cyanide (otherwise known as acrylonitrile) began to be produced in 1959, at the ICI Billingham plant, for use in the manufacture

1. See H. A. Moisley, 'The Rayon Industry in Great Britain', *Geography*, **34**, 1949, 78–89.

of synthetic rubber. Somewhat earlier it had been used in the United States as a fibre, and in 1963 the Monsanto subsidiary Chemstrand began making Acrilan at Coleraine in Northern Ireland. Other acrylic fibres (polyacrylonitrile), known under various trade names such as Courtelle, are produced in Courtauld factories at Coventry and Grimsby.

*Polypropylene* (methyl ethylene) was developed in America and first made in Britain in 1959 by the ICI complex at Wilton, marketed as Propathene. It is based on the products of naphtha cracking at oil refineries. In 1963 ICI started production at its Kilroot plant, where the material is marketed as Ulstron. It can be used as fibre, film or as mouldings.

The geography of the manmade fibres industry clearly shows a number of different influences at work, but the most obvious are attachment to a pre-existing textile industry (e.g. Coventry), or to a great HOC complex (e.g. Wilton), and government encouragement in the Development Areas (e.g. Pontypool and the various centres in Northern Ireland). Manmade fibres are indeed a major prop to the economy of the last-named area (cf. p. 576).

## Plastics

The development of the plastics industry, like that of synthetic fibres, is essentially a part of the industrial revolution of the mid-twentieth century. And yet Alexander Parkes produced his Parkesine from cellulose nitrate (nitrocellulose) with castor oil as early as 1861 and in a paper read to the Royal Society of Arts in 1865 he anticipated many of the modern uses of plastics. The American J. W. Hyatt using cellulose nitrate and camphor produced Celluloid in 1869, and Daniel Spill (Parkes's assistant) introduced Xylonite—still made—about the same time. Scientific progress was made but slowly, however. The effective foundation of the industry may be dated from about 1907, when L. H. Baekeland in America discovered a process for producing technically useful resins by reaction of phenol with formaldehyde; this material—subsequently known as Bakelite—was first made in England in 1916, and large-scale operations began at Tyseley, near Birmingham, in 1931.

The plastics industry is thus mainly a product of the last three or four decades. Of small importance before the late 1920s, it was greatly stimulated by the rapid growth of the electrical and radio industries, and great advances were made during the Second World War. The output increased more than fourfold during the decade 1938–48, and has continued to rise steeply. Production in 1961 reached 619 700 metric tons (610 000 long tons), doubling again to 1 239 400 metric tons (1 200 000 long tons) in 1968, in which year the value of the goods produced was about £700m. Over one quarter of the output is exported directly, and a good deal more as components of, for example, cars and refrigerators.

At present roughly a fifth of the total production enters the packaging industry (everything from film wrapping to egg boxes, meat trays and all kinds of bottles and bags); another fifth is taken by the building industry, for guttering, pipes and taps, tiles, chipboard, etc. Two other industries—domestic appliances and household goods and the automotive industry—take another 15 per cent each. Something like 32 kilograms (70 lb) of plastics go into the average car—and the Concorde aircraft contains no less than 2000 plastic components. New plastics are constantly being evolved that will add flameproof, heat-resistant and long-life characteristics to existing electrical and chemical resistance properties, and new materials, such as plastics reinforced with carbon fibres, may have qualities that compare with steel. 'The potential for plastics consumption extends into virtually every industrial sector and plastics are increasingly substituting for materials ranging from glass through pottery, leather and lubricating oils to textiles and metals.'[1]

The plastics industry, like that of manmade fibres, consists of two parts, the actual production of the synthetic resins and moulding powders, which is a chemical industry, and the manipulation of the materials to produce a multitude of industrial components and consumer goods. In 1966 39 000 people found employment in the production of plastics, and a further 95 000 were engaged in plastics moulding and fabricating. As with synthetic fibres, the basic chemicals, which are derived essentially from byproducts of petroleum refining and coal-tar distillation, are married together, by the process known as polymerisation, into plastic materials. There are two major types: (1) thermosetting plastics, which harden by chemical action brought about by heating and cannot subsequently be softened again; they are moulded by compression; (2) thermoplastics, which are moulded by injection or are produced in flexible sheets, rods or tubes, in a wide range of colours. The thermosetting plastics are based on phenol (derived from coal-tar), formaldehyde (from carbon monoxide and hydrogen) and urea (from ammonia and carbon dioxide); they are used for such things as door knobs, laminated sheet, plastic crockery, electrical insulators, tabletops, etc., in paint manufacture and as a bonding material in plywood and furniture. The thermoplastics are of two kinds, those derived from cellulose, the manufacture of which depends on imported cotton linters, and the synthetic materials, derived mainly from coal and petroleum and using also salt and limestone. The synthetic plastics are of fairly recent development, mainly during and since the Second World War; like the synthetic fibres, they are polymerisation products. They include: polythene (based on ethylene derived from oil cracking), used mainly in film form as a wrapping material; Perspex or glass-substitute (derived from acetone); polyvinyl chloride (PVC—based on carbide and chlorine), much in use for raincoats, curtains, table-covers, handbags, wall, floor and seat

1. Supplement to *The Times*, 17 June 1969.

coverings, gramophone records, etc.; polystyrene (from benzene and ethylene), used for toys, table-ware, toilet articles, radio parts, etc.; and polyurethane, used mainly in foamed form for packaging and insulating.

The main sources of the fundamental chemicals used in the industry are of course the great chemical works of ICI—Billingham and Wilton, Northwich, Runcorn, Fleetwood—and the petrochemical works associated with coastal oil refineries (e.g. Stanlow, Fawley, Grangemouth). But the wide variety of raw materials employed, both home produced (coal derivatives, salt, limestone) and imported (petroleum, carbide, cotton linters, wood pulp, resins, etc.) and the equally wide variety of products and markets, result in a widespread distribution both of the making and the utilisation of plastics. Moreover the industry has been taken up by many firms previously engaged in other or allied trades, and so it is not easy to generalise about location factors. But since there is little wastage of raw materials during manufacture, labour supply and markets rather than raw materials tend to be of most significance—hence the importance of the Greater London and Birmingham areas, for example; whilst the light and largely footloose character of the manipulation side of the industry has made it a suitable one for setting up in the New Towns and in Development Areas. The list of localities contains more unexpected and not readily explicable places than is the case with any other manufacturing industry.

There is one last plastic industry that differs from all others in that it is based on inorganic materials. Silicone polymers, used as water-repellent agents and for purposes where a chemically resistant plastic is needed, have a silicon (i.e. sand) base. Production takes place at the ICI works at Ardeer in Ayrshire, at Oldbury near Birmingham and at Barry in South Wales (localised by the availability of a wartime magnesium-from-sea-water factory). Silicones can be produced in the form of liquids, semi-solids and solids; they are used as impregnants, thermally-resistant coatings, waterproofing agents, polishes and lubricants.

## Soap and detergents

The early history of the soap industry, and its relationship to alkali manufacture, have already been referred to. In the early days almost any fat or oil was used, and the soap-boiling works were widely scattered. Large-scale production based on imported vegetable oils led inevitably to a concentration on major ports, and the business of Lever Brothers is a good example. W. H. Lever selected a site on the Wirral side of the Mersey estuary, because 'it was a rural area where ample acreage could be secured adjacent to both rail and water transport with reasonable facilities for obtaining the necessary supply of labour'; and the result was Port Sunlight works and 'garden city'. It was also conveniently near to the alkali industry of Merseyside. The Lever interests gradually absorbed many other soap-making companies; and there was close connection also with those who were using

vegetable oils for other purposes, such as the British Oil and Cake Mills, Ltd, and finally in 1920, came the merging of interests with the Margarine Union, which had been using similar materials for the manufacture of margarine. The whole great combine is known as Unilever, and its manufacturing business extends into fifty countries and employs more than a quarter of a million people.

Although Port Sunlight dominates the industry, there are other centres in Lancashire, notably Warrington. Outside Merseyside, the London port area, Tyneside, and several centres in Scotland such as Renfrew, Paisley and Grangemouth are concerned with soap manufacture.

The soap industry has turned in part to new products—synthetic detergents or 'syndets', which are now flooding the market under numerous proprietary names. These detergents—which started as soap substitutes and have turned out to be in fact very much better than soap for many purposes, particularly with hard water—are made for the most part from oil refinery products, and both the soap firms and the petrochemical interests are involved. The industry began in the early 1930s with soapless shampoos produced by Hedley's and Unilever, and with Shell's Teepol, but since 1957 the main product has been a detergent alkylate, made on Tees-side and elsewhere. The use of these detergents created considerable problems of indestructible foam that affected sewage effluents, streams and rivers, and which are still not completely solved.

## Other chemical industries

There are many other chemical industries that deserve more than a passing mention, and the geographical influences on their location are diverse. It is clear, however, that the labour supplies and markets provided by the great conurbations play an important part, for the raw materials are often of diverse origins and of relatively small bulk. Thus whilst the London area has scarcely been mentioned so far in this chapter, a glance at the table on p. 588 will show that it is in fact the most important region of all in terms of employment in chemical manufacture, particularly in the fields of toilet preparations and perfumery, drugs and pharmaceuticals, i.e. what are usually known as 'fine chemicals', produced for specialised application rather than for a range of uses.

The range of *biologically active chemicals* has increased enormously during the last half-century, mainly as a result of the synthesis of these substances, which modify the behaviour of living organisms by participating in their biochemistry. In the presynthetic age pharmaceuticals were mainly derived from the roots and leaves of plants and from a few chemicals such as Glauber's salt; there was little or no scientific or theoretical basis to their preparation until the middle of the nineteenth century, and there was no manufacture of synthetic pharmaceuticals in Britain before the First World War. Probably three-quarters of all the drugs and medicines in use today

were unknown forty years ago; insulin, adrenaline and the preparation of vitamins go back to the 1920s, but products of such far-reaching significance as penicillin, cortisone, the anaesthetic 'fluothane', and the birth control pill, have all been developed since 1940. There is an interesting connection with the synthetic dyestuffs industry in that much of the fundamental research in organic chemistry is of a similar nature. ICI entered the pharmaceutical field in 1936 by forming a medical section within its dyestuffs research division, and though Pharmaceuticals is now a division in its own right, some products are still made at factories within the Dyestuffs division. There are also connections with the foodstuffs industries—a special Unilever subsidiary concerned with the production of vitamins for adding to margarine and animal feeding stuffs was formed in 1946—and with distilling.

The pharmaceutical industry is in the hands of some 500 firms, mostly small and specialised, with a few giant combines such as ICI, Beecham and Boots. The Greater London area—including some of its newer industrial centres such as Welwyn Garden City and Dagenham—is by far the most important, with Manchester, Liverpool and Edinburgh. The case of Nottingham is an interesting example, comparable with Oxford and its motor car works, of a great industry arising from very small beginnings. The parents of Jesse Boot happened to have a small herbalist business in the city, which in 1888 became a retail chemist's shop with its own manufacturing side.

Another side of the biologically active chemicals industry is concerned with *pesticides* and *weed-killers*, in which some 150 different chemicals are now involved. Vine-spraying with lime and sulphur began in France in 1851, but the British industry is largely post-First World War. Considerable developments took place between the wars, in the use of copper salts, derris, pyrethum, tar oil, and so on, and both ICI and Boots entered the field in the 1930s. The link with the fertilisers industry is an obvious one. ICI and agricultural interests formed Plant Protection Ltd in 1937 and the fertiliser firm of Fisons formed Pest Control Ltd in 1954, with a large factory at Harston near Cambridge. Developments since the Second World War have been rapid, especially of insecticides (e.g. DDT), selective weed-killers (e.g. 2,4-D) and the newer general herbicide 'paraquat'.

The main *fertiliser* industry is of much longer standing, as noted above (p. 581). Dependent partly on imported raw materials (phosphates) and partly on home-produced chemicals (e.g. sulphate of ammonia), and having a widespread agricultural market, it is fairly well scattered, with an emphasis on port locations and on centres (e.g. Ely) within the main agricultural areas.

*Paint and varnish* manufacture, depending on pigments, solvents, oils and resins, is a large employer of labour in several of the major industrial districts, particularly Greater London, south Lancashire and the West Midlands; in

Glasgow and on Tyneside it is clearly linked with the shipbuilding industry. To an increasing extent it is drawing on the products of the heavy organic chemicals industry, replacing its older natural materials with synthetic products.

## Exports of chemicals

The following tables demonstrate the importance of the considerable export trade in chemicals, the value of which rose from an average of £29m a year in 1935–38 to £178m in 1953, £295m in 1959 and £493m in 1967.

*Exports of chemical products, by value* (£ millions)

| PRODUCT GROUP | 1959 | 1963 | 1967 |
|---|---|---|---|
| Chemical elements and compounds | 70 | 93 | 118 |
| Dyeing, tanning and colouring materials | 40 | 48 | 58 |
| Medicines and pharmaceutical products | 46 | 54 | 78 |
| Essential oils and perfume materials | 30 | 34 | 43 |
| Fertilisers, manufactured | 3 | 5 | 8 |
| Explosives &c. | 10 | 7 | 9 |
| Plastics | 45 | 64 | 94 |
| Others | 51 | 63 | 84 |
| | 295 | 368 | 493 |

*Exports of chemical products, by weight* (thousand tons)

| PRODUCT | 1938 METRIC TONS | 1938 LONG TONS | 1948 METRIC TONS | 1948 LONG TONS | 1959 METRIC TONS | 1959 LONG TONS | 1967 METRIC TONS | 1967 LONG TONS |
|---|---|---|---|---|---|---|---|---|
| Ammonium sulphate &c* | 318 | 313 | 224 | 221 | 218 | 215 | 373 | 367 |
| Copper sulphate | 31.4 | 31 | 25.3 | 25 | 31.4 | 31 | 12.1 | 12 |
| Disinfectants and insecticides | 19.2 | 19 | 34.4 | 34 | 28.4 | 28 | 43.6 | 43 |
| Sodium compounds | 362 | 356 | 419 | 413 | 615 | 605 | 603 | 593 |
| Dyes and dyestuffs | 15.1 | 15 | 18.2 | 18 | 12.1 | 12 | 21.3 | 21 |
| Soaps | 37.5 | 37 | 28.4 | 28 | 50.8 | 50 | 25.3 | 25 |
| Detergents | | † | | † | 46.6 | 46 | 58.9 | 58 |

* Including other nitrogenous fertilisers in 1959 and 1967.

† Not available (but virtually non-existent).

About 60 per cent of the exports, by value, leave from the ports of London and Liverpool—the latter because of the wide range of heavy chemical industries in its immediate hinterland, the former because of the high-value products that are made in its many 'fine chemicals' factories. Middlesbrough and Hull—each with chemical industries of its own—are a very long way behind, followed by Manchester and a long list of ports that export in small quantities.

# 23
# Miscellaneous industries

In the preceding chapters we have dealt in turn with the major industries of Britain. It is true that we still have some miscellaneous manufacturing industries to consider but, even allowing for these, there remains the remarkable fact that well over half the population of these islands has still to be accounted for. It is worth while to study with some care the tables which follow in that they illustrate the relative importance of the occupations not yet considered.

## The service industries

One of the characteristics of the employment structure of 'developed' countries is the increasing proportion provided by what is known as the 'tertiary' sector—that is, the service industries as opposed to extractive industries and agriculture (primary) and manufacturing (secondary). Britain is no exception to this generalisation, and indeed if 1959 figures are regarded as 100, the figures for 1964 were primary 80.3, secondary 105.0 and tertiary 109.9 (the total employment having risen to 106). In the same year (1964) the actual figures of employment were primary 1 181 000, secondary 8 700 000 and tertiary 12 950 000, the tertiary representing 55 per cent of the total.

In the table on p. 600 the service industries are listed at the bottom, from 'construction' to 'public administration'.

*Distribution of total manpower, Great Britain* (thousands)

| | 1938 | 1961 | 1966 |
|---|---|---|---|
| Total population | 46 208 | 51 350 | 54 744 |
| Males | 22 197 | 24 833 | 26 602 |
| Females | 24 011 | 26 517 | 28 142 |
| Total working population | 19 473 | 24 650 | 26 236 |
| Males | 14 476 | 16 325 | 17 045 |
| Females | 4 997 | 8 325 | 9 191 |

| | 1938 | % | 1961 | % | 1966 | % |
|---|---|---|---|---|---|---|
| HM Forces and Women's Services | 385 | (2) | 474 | (2) | 417 | |
| Males | 385 | | 459 | | 402 | |
| Females | — | | 15 | | 15 | |
| Agriculture, forestry, fishing | 949 | (5) | 604 | (2) | 478 | |
| Mining and quarrying | 849 | (4) | 731 | (3) | 580 | (2) |
| Manufacturing industries: total | 6 363 | (33) | 8 928 | (36) | 9 055 | (34) |
| Food, drink and tobacco | 640 | (3) | 832 | (3) | 841 | (3) |
| Chemicals and allied industries | 276 | (1) | 532 | (2) | 528 | (2) |
| Metal manufacture | | | 631 | (2) | 619 | (2) |
| Engineering and electrical goods | | | 2 147 | (9) | 2 337 | (9) |
| Shipbuilding | 2 590 | (14) | 241 | (1) | 214 | |
| Vehicles | | | 898 | (4) | 861 | (3) |
| Other metal goods | | | 567 | (2) | 596 | (2) |
| Textiles | 861 | (5) | 842 | (4) | 810 | (3) |
| Clothing and footwear | 717 | (4) | 585 | (2) | 552 | (2) |
| Bricks, pottery, glass, cement, etc. | 271 | (1) | 346 | (1) | 352 | |
| Leather, leather goods and fur | | | 67 | | 60 | |
| Timber, furniture, etc. | 844 | (4) | 308 | (1) | 296 | |
| Paper, printing and publishing | | | 621 | (2) | 648 | (2) |
| Other manufacturing | 164 | (1) | 309 | (1) | 342 | |
| Construction | 1 264 | (6) | 1 617 | (7) | 1 725 | (7) |
| Gas, electricity and water supply | 240 | (1) | 379 | (2) | 431 | |
| Transport and communication | 1 225 | (6) | 1 683 | (7) | 1 629 | (6) |
| Distributive trades | 2 882 | (15) | 3 312 | (13) | 3 035 | (11) |
| Insurance, banking and finance | 414 | (2) | 573 | (2) | 3 222 | (12) |
| Professional and scientific services | 1 806 | (9) | 2 217 | (9) | | |
| Miscellaneous services | | | 2 270 | (9) | 2 246 | (9) |
| Public administration | | | | | | |
| National government service | 1 386 | (7) | 511 | (2) | 579 | (2) |
| Local government service | | | 756 | (3) | 804 | (3) |
| Unemployed total | 1 710 | (9) | 261 | (1) | 281 | |

In 1938 the working population was 42 per cent of the total population (65 per cent of males, 21 per cent of females); in 1961 it was 48 per cent of the total (66 per cent of males, 31 per cent of females); in 1966 it was still 48 per cent, but males had dropped to 64 and females rose to 33. Percentages given above are of the working population.

Perhaps the most striking fact emerging from the table on page 601 is the important, often dominant position occupied by the London area in almost all these miscellaneous industries. The reason is to be found partly in London's premier position as a port for the import of all manner of raw materials, but mainly in the existence within the conurbation of some ten millions of people, providing both a source of labour and an immense market for all the necessities and luxuries of civilised life. London's industrial structure will be referred to in some detail in Chapter 26.

We may begin our examination of these miscellaneous industries with the only one in which London plays little or no part—the pottery industry.

*Miscellaneous manufacturing industries employment, 1948 and 1960*

| INDUSTRY | NUMBER EMPLOYED (THOUSANDS) 1948 | 1960 | CHIEF REGIONS[1] APPROXIMATE PERCENTAGE OF TOTAL |
|---|---|---|---|
| China and earthenware | 67 | 68 | Midland (85). |
| Glass and glassware | 62 | 77 | NW (30), London and SE (23), Yorkshire (16). |
| Leather and leather goods | 49 | 55 | NW (20), London and SE (12), Yorkshire (10). |
| Boots and shoes | 114 | 117 | N. Midland (51), NW (11), London and SE (8). |
| Tailoring and dressmaking | 384 | 399 | London and SE (25), NW (18), Yorkshire (15), N. Midland (8). |
| Furniture and upholstery | 93 | 109 | London and SE (33). |
| Paper and board | 66 | 94 | London and SE (22), Scotland (22), NW (20), SW (9). |
| Printing and publishing, etc. | 190 | 378 | London and SE (34), Scotland (9), NW (9), E. (7), Yorkshire (7). |
| Rubber | 89 | 124 | NW (30), Midland (22), London and SE (18), Scotland (11). |
| Building and contracting | 1505 | 1505 | Greater London (16), Scotland (7), SE (7), Lancashire and Cheshire (7). |
| Tobacco | 45 | 49 | * |

[1] Ministry of Labour Regions.
* Not available, as regions lumped together

## The ceramic industries

According to the Census of Production, 1948, no less than 85 per cent of all the pottery workers in Great Britain were in the Midlands Region. In fact the concentration is narrower than this and within the Region almost the entire industry is located in the city of Stoke-on-Trent—one of the most remarkable industrial concentrations in the world. The 'Five Towns' of Arnold Bennett's novels (there are actually six, but he omitted Fenton) have become so identified with the pottery industry, that they are known all over the world as 'The Potteries'. The North Staffordshire coalfield (see p. 301) lies in the southwest corner of the Pennine Uplands, drained by several small streams—of which the most important is the Fowlea Brook—which unite to form the upper Trent, and separated by a low and broken ridge from the Cheshire Plain. In early times it was distinctly isolated, and from about the fourteenth century it seems that the local wood and clays, and later the local coals, were used to make coarse earthenware as a sideline to subsistence farming. By the early eighteenth century the village of Burslem had become quite a noted centre, making, amongst other things, butter-pots for sending Uttoxeter butter to London. Old maps show clearly the

crofts with their pottery kilns adjacent to the dwelling or to the barn, and the small clay-holes from which the raw material was obtained. Lead and salt for glazing were accessible from the Derbyshire limestone area and from Cheshire, respectively. The clays came from the Blackband Group at the base of the Upper Coal Measures—which outcropped in Burslem and Hanley—and the long-flame coals from the adjacent upper part of the Middle Coal Measures. Devon and Dorset ball clays, and south coast flints, were imported by pack-horse for making finer ware, and the construction

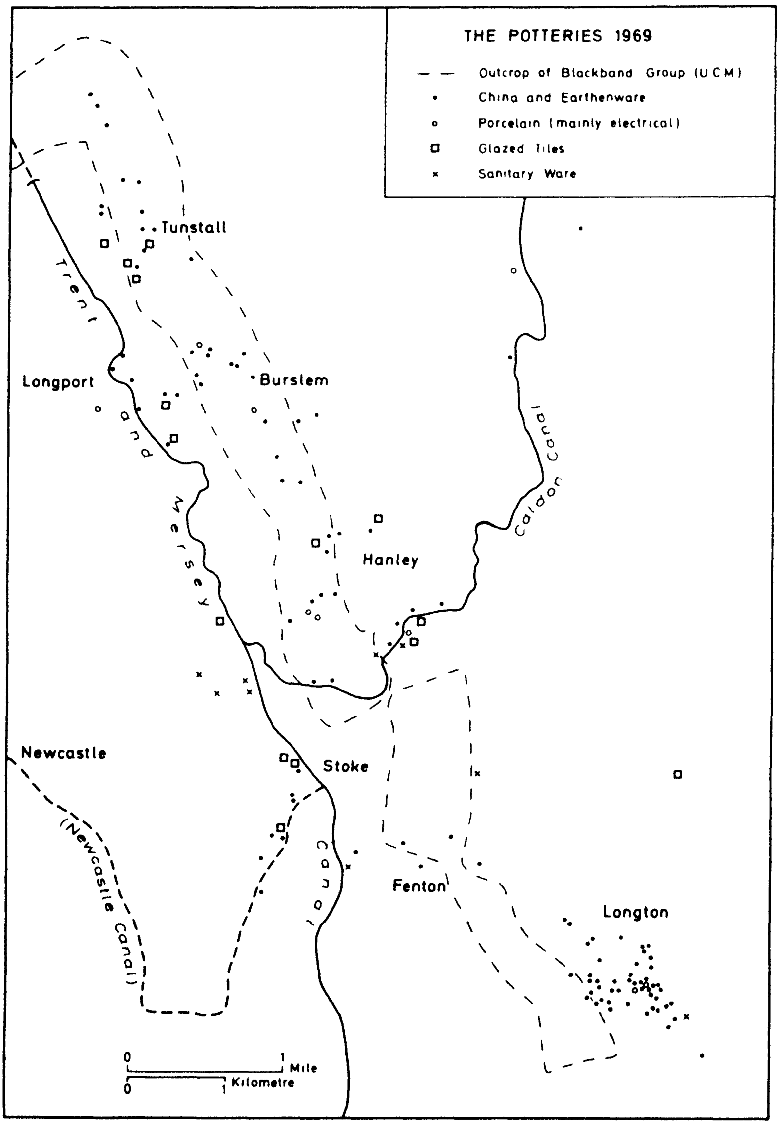



FIG. 205. The Potteries, 1969

of turnpike roads led to the growth of the industry in Longton, at the point where the Derby–Newcastle road crossed the main coal and clay outcrops.

Amongst the skilled families of potters in the mid-eighteenth century were the Wedgwoods. Josiah Wedgwood (1730–95) was a farsighted business man as well as an expert craftsman. It was he who introduced Cornish china clay into the potteries in the 1760s; he, too, who was a leading spirit behind the construction of the Trent and Mersey Canal, opened in 1777, alongside which he placed his Etruria Works. The canal, linking the Trent near Derby with the Mersey at Runcorn, and passing through the western ridge of the coalfield in the famous Harecastle tunnel, gave direct water connection between Cornwall and North Staffordshire. But, curiously enough, the potteries did not migrate to its banks; they remained where they were, in the rapidly growing small towns, for between five and twelve tons of coal were needed for every ton of clay, and the collieries were located close to the towns, whilst the canal ran down the Fowlea Brook valley, which follows the Etruria Marl (barren red Upper Coal Measures) outcrop. The early nineteenth-century location of the industry has thus remained unchanged to the present day. The vast majority of the potteries are still in the built-up areas of Tunstall, Burslem, Hanley, Fenton, Longton, and Stoke; the only canal-side potteries are at Longport (where the old turnpike road from Burslem to Newcastle crossed the canal), at Stoke, and at Hanley (where the Caldon Canal crossed the Blackband outcrop). The china section of the industry (as opposed to earthenware) is located almost entirely in Longton, actually the farthest of all the towns from the canal. Only one firm so far—Wedgwoods—has attempted to leave the congested urban area; in 1939 the old Etruria works were abandoned and a completely new factory, with electric firing and rail transport, was established at Barlaston, a few miles south of Stoke. Two other large works outside the urban area are specialists in the production of electrical porcelain; each lay alongside a canal—one at Stone by the Trent and Mersey Canal, the other at Milton, by the Caldon Canal.

But several 'potters' millers' are located on the canal banks, where many of the raw materials (china clay, china stone, ball clay, flint, chert, felspar, calcined bones, etc.), used to arrive by water and are prepared for the potters. Accompanying the pottery industry are subsidiary industries concerned with the supply of colours and glazes; and Stoke is the headquarters of the British Ceramic Research Association.

The economic geography of the pottery industry has changed fundamentally since the last war. No coal is now used for firing—gas, electricity and oil fuel have been substituted (thus incidentally removing the greater part of the smoke problem in Stoke)—and the china clay arrives from Cornwall by 'clay-liner' railway trains. Only the location remains unchanged, and many of the potteries have been rebuilt on their existing sites. The limited amount of mechanisation that is possible in this industry has re-

duced the labour requirements, and the employment roll dropped from 53 000 in 1958 to 43 000 (of whom 24 000 female) in 1968.

China and earthenware are not the only clay industries in the Potteries. The Coal Measures' fireclays were the basis of the manufacture of saggars (the containers in which the china and earthenware are placed for firing in the kilns), and of glazed tiles, sanitary ware and sewage pipes, and of refractory products. The purple mudstones of the Etruria Marl supply not only a flourishing brick industry, but also over one-half of all the clay roofing tile industry in the country. The tile industry, unlike the pottery trades, spreads beyond Stoke-on-Trent into the neighbouring borough and ancient market town of Newcastle-under-Lyme.

The ceramic industries outside the Potteries are located almost entirely on their source of clay supplies. Thus the Dorset and Devonshire potteries are located on the ball-clays of Poole and Bovey Tracey respectively. Some of the famous china industries of the past—at Worcester, Coalport, and Derby, for example—are now either extinct or of relatively little importance. The sanitary ware industry, based upon Coal Measures' fireclays, is to be found in such places as Swadlincote (south Derbyshire), Halifax, and Barrhead (near Glasgow).

## Fur, and the leather-producing industries[1]

In its distribution the fur industry of Britain is almost entirely distinct from the ordinary leather industry. The dressing and preparation of furs is very largely restricted to London where, in the East End, it employs a large number of people. Three-quarters of the 11 000 workers in the industry are in London and they produce nearly three-quarters of the total output by value. With regard to the *leather* industry, the distribution of tanning and leather dressing in Britain is of considerable geographical interest. Tanning is an old industry and whilst production techniques have changed in detail, the general sequence of operations by which raw hides and skins are transformed into leather has remained broadly the same since very early times. The main stages in the process of production are as follows:

(*a*) *Washing and soaking*. When the hides arrive at a tannery they are often dirty and very stiff. Washing and soaking in water removes some of the dirt and makes them pliable.
(*b*) *Dehairing*. To remove hair from the hides and skins they are immersed in a solution of lime. This causes the skins to swell and the hairs to fall out and partially dissolve.
(*c*) *Fleshing*. After dehairing the hides may still retain shreds of animal

1. This and the next section (pp. 608–612) have been rewritten by Dr P. R. Mounfield, to whom I am much indebted.

flesh. At this stage these are removed by machine scraping or, occasionally, by hand.

(*d*) *Drenching and deliming.* The lime used in dehairing is still on the skin. It is removed during this process by soaking in water.

(*e*) *Tanning.* Tanning is designed to preserve the hides, make them waterproof and to improve their flexibility and wearing qualities. The tanning liquor can be either a solution of vegetable extracts or mineral salts. The latter is nowadays more common for the soft leathers required for shoe uppers, gloves and other leather clothing.

(*f*) *Finishing or dressing.* In this process the leather is oiled, stretched and polished. Some of the leather may have designs stamped upon it whilst other hides may be treated to give a high gloss.

In large tanning firms, all these processes may be carried out in the same premises but it is not uncommon for the final stage of finishing or dressing to be carried out by separate firms. About half the leather-producing firms in Britain start with the raw hides and skins and either finish them right through or sell them 'in the crust' (or rough-tanned state). Others buy the 'crust' leather, from either British or foreign suppliers, and dress it to produce the finished material. It is important to note this distinction between tanning and leather dressing, because they exhibit rather different locational characteristics. The two sections of the industry together employ approximately 35 000 workers.

The nature of the production processes indicates the main requirements of the *tanning* industry to be (*a*) a reliable supply of hides and skins, (*b*) mineral or vegetable tanning agents, (*c*) copious supplies of clean and preferably soft water, (*d*) lime for dehairing. In medieval times tanneries were very small and widely scattered throughout the country; practically every village of any size had its own tan pits. Hides and skins were obtained locally and oak bark, for a considerable period the main source of tanning liquor, was obtained from local woodlands. The individual tanneries served strictly local markets and the smaller ones were frequently ancillary to a farmer's business and worked by farm labour as part of the farm. With the passage of time, however, tanning became a more specialised and separate craft. The complete tanning process was a long one; in medieval tanyards a hide might take twelve months to prepare, and even as late as 1925 the usual period for sole leather was five to six months. This meant that, as it progressed as a separate activity, the industry became one that required increasingly large amounts of capital. Furthermore, as the demand for leather increased, and as individual tanneries became larger, the question of oak bark supplies became progressively more important. The oak bark itself was fragile, bulky and produced only 10 to 20 per cent tannin liquor. This in turn led to an increased concentration of tanning on or near to the large oak forests which grew both on the damp lowlands of central England and on the drier sandstone ridges such as those of the Bunter sandstone. Further-

more, the 'New Husbandry' of the seventeenth and early eighteenth centuries meant that a large proportion of the heavy claylands in the Midland shires was put down to grass. These grass pastures became famous fattening areas for the herds of cattle that were driven to the London meat markets from as far afield as Wales, Shropshire and Cornwall. A constant and reliable supply of hides was thereby assured, and some of the old-established Midland towns, such as Northampton, became important centres for the organisation of the tanning industry. Another centre of early importance was the natural focus of the great agricultural region of East Anglia, that is, Norwich.

However, the nineteenth century witnessed a general decline in the number and relative importance of inland tanneries in Britain. This was mainly due to the increasing dependence of the industry on imported hides and imported vegetable tanning concentrates—a dependence which placed a premium on coastal locations and led to the growth of tanneries at the large ports such as Liverpool, Bristol and London.

In the 1890s, just when it seemed that what remained of the tanning industry in inland centres was doomed to final extinction, a new and revolutionary process was introduced in the industry. This was mineral tanning. Hitherto, tanning agents had been obtained exclusively from vegetable sources such as oak bark and hemlock. Now, it was discovered that chrome salts could be used. By using chrome salts, tanners were able to give a finer and more uniform finish to their products and mineral tanning quickly superseded vegetable tanning, particularly in the tanning of softer leathers, such as those used for shoe uppers. The tanners using vegetable tanning solutions began to specialise in the production of tough, durable leather of the type used for machine belting and the soles of shoes. A large proportion of their hides were imported, from the Argentine, the Union of South Africa, India, Eire and other cattle rearing countries. Thus, the heavy-leather tanneries remained at the ports. Mineral tannage, on the other hand, served to revive the industry in some of the old inland centres as in Northamptonshire, for example, where the footwear industry had grown rapidly at a number of places during the second half of the nineteenth century and provided an important local market for the tanners' products.

Tanners treat raw hides and skins, but not all of their output is fully finished. Moreover, a substantial proportion of the imported hides and skins now enter Britain in a semitanned state and may not go to the tanner. These hides have been rough-tanned in the exporting countries in order to decrease their weight before shipment. Imported leather is subject to lower tariffs if it is semitanned rather than in a finished condition. In addition, for many purposes leather has to be finally worked up near its market because its finished form is dependent upon the dictates of fashion. Thus, it might reasonably be expected that the *leather dressing* industry as a separate trade would be in the same areas of the country as those industries which use leather as their main raw material. This is certainly the situation in

Northamptonshire, where the centres of leather dressing are also shoe manufacturing towns. Indeed, it is leather dressing rather than tanning that has gained from the presence of footwear production in the southeastern Midlands.

The history of leather dressing as a separate occupation is relatively short. Until a century ago, all imported hides entered the country in a raw and virtually untreated state: they went directly to the tanneries, which undertook all the processes of leather manufacture. The first fundamental division between tanning and leather dressing appeared when rough-tanned leather began to be imported in quantity, from about the middle of the nineteenth century. In Northamptonshire the footwear industry was expanding at this time, but the local tanning industry was declining; the leather dressing industry largely took its place. Sometimes old tanneries were converted into leather dressing works but more frequently new buildings were erected, for the old tanneries included a considerable amount of space for tanning pits which was not needed for leather dressing. Nowadays the chief product of the Northamptonshire dressers is a high-grade upper leather, together with lining and slipper leathers. The leather dressing works are generally smaller than the tanneries, each tends to have its own speciality, and no individual works employs more than fifty workers. However, leather dressing in Northamptonshire employs a much larger *total* labour force than tanning.

Thus, there are three types of area where tanning and leather dressing are important at the present day:

(*a*) The old centres in the heart of the country districts, particularly in Northamptonshire, associated with the manufacture of boots and shoes, as well as in Somerset and other southern counties, where it was and often still is linked with local supplies of sheepskins and with the glove industry (p. 613);

(*b*) in the vicinity of the great ports, particularly Merseyside (Liverpool, Warrington and Runcorn), Bristol and London, where the emphasis (mainly the result of hide imports) has been on heavy leathers for the soles of boots and shoes;

(*c*) in the great inland industrial conurbations (West Yorkshire, South Lancashire, and the West Midlands), where the market provided by various types of demand, particularly the use of leather belting for driving machinery in the textile and engineering industries, has been an influential factor.

It must be noted, however, that the heavy leather tanneries have suffered considerably in recent years through the decline in demand for machine belting, through the decreasing use of leather as a sole material in the footwear industry (see table on p. 609) and through competition from a variety of synthetic products.

## Leather-using industries: especially footwear manufacture

The small-scale making of leather goods was formerly very widespread throughout the rural counties of England and Wales. These leather workers were, in the main, either saddlers, whose occupation has almost disappeared with the increasing mechanisation of agriculture, and bespoke shoemakers, who similarly have been put out of business through the growth of factory-made footwear. The manufacture of both footwear and leather goods is now concentrated in particular parts of the country. The production of leather bags, trunks, saddlery, and similar articles tends to be concentrated in the Greater London area (which has 40 per cent of the 25 000 people employed), and also in the west Midlands (21 per cent), principally at Walsall. It has already been mentioned that, before modern methods of transportation and food preservation were developed, most of London's meat supply was provided by herds of cattle driven long distances to the London meat markets from the rural rearing and fattening districts. The hides of these animals were processed by London tanners and provided the basic material for local leather workers. In the Middle Ages Birmingham was a smaller and less important place than Worcester, Coventry, Warwick and Stafford, but it became a natural centre, albeit on a somewhat infertile plateau, for the surrounding rich fertile lowlands, and, like the iron hardware industry (cf. pp. 409, 453), the leather industry may be regarded as having grown out of an early response to local farming requirements and local supplies of raw material.

The footwear industry, which employed over 100 000 workers in 1961, has become concentrated in a remarkable way in a few areas (see table opposite).

In the Middle Ages, and even later in remoter parts of the country, individual households commonly made their own shoes. The everyday shoes of the working classes during the Middle Ages were extremely simple leather 'envelopes' worn over tight stockings. The workmanship was of a comparatively crude but sturdy nature, requiring little skill. It was not until horse-riding became more common that the heel was introduced, enabling the foot to be held more securely in the stirrup. After this technical innovation, shoemaking became more of a separate craft. Even so, virtually every village and town in the country had its own shoemakers, producing a local supply of shoes and using local materials (in those parts of the country where leather was in short supply, wood was sometimes substituted for leather soles). At this stage, there was little sign of any concentration of the industry in particular parts of the country. Since each pair of boots had to be made to measure, the shoemaking craft was distributed in accordance with the pattern of population.

It was not until the military spirit of the seventeenth century made itself felt that the need for large quantities of strong and serviceable footwear,

*Statistics for the major footwear manufacturing districts of Britain, 1955 and 1965*

| AREA | NUMBER OF FIRMS | | OUTPUT (THOUSAND PAIRS) | | LABOUR FORCE | | PERCENTAGE OF OUTPUT WITH NON-LEATHER SOLES | |
|---|---|---|---|---|---|---|---|---|
| | 1955 | 1965 | 1955 | 1965 | 1955 | 1965 | 1955 | 1965 |
| London, Chesham and East Tilbury | 55 | 36 | 10 053 | 15 754 | 6 092 | 4 781 | 51 | 91 |
| Bristol, Kingswood and Street | 26 | 8 | 7 204 | 20 892 | 6 748 | 10 988 | 58 | 97 |
| Kendal and Scotland | 6 | 4 | 2 757 | 5 305 | 3 852 | 4 875 | 12 | 69 |
| Leeds | 12 | 8 | 3 182 | 2 372 | 2 060 | 1 052 | 44 | 90 |
| Norwich | 27 | 22 | 7 065 | 8 556 | 9 008 | 7 628 | 30 | 76 |
| Desborough, Rothwell and district (Northants) | 11 | 8 | 2 065 | 2 399 | 1 637 | 1 502 | 24 | 65 |
| Kettering and district (Northants) | 25 | 16 | 5 610 | 5 444 | 5 645 | 4 588 | 23 | 56 |
| Rushden and district (Northants) | 77 | 69 | 12 980 | 14 273 | 11 763 | 10 295 | 25 | 67 |
| Northampton | 38 | 24 | 7 144 | 7 764 | 10 543 | 7 241 | 15 | 67 |
| Leicester | 76 | 55 | 13 430 | 14 369 | 11 703 | 8 792 | 34 | 97 |
| Leicester county (excluding Leicester) | 66 | 57 | 18 523 | 22 459 | 11 616 | 10 830 | 55 | 99 |
| Stafford and Stone | 9 | 4 | 1 738 | 2 570 | 2 141 | 2 361 | 22 | 93 |
| Lancashire (especially Rossendale) | 54 | 38 | 28 280 | 30 705 | 12 056 | 10 117 | 74 | 99 |
| Total | 482 | 349 | 120 031 | 152 862 | 94 864 | 85 060 | 36 | 82 |

*Note* Data provided by the Footwear Manufacturers Federation and the Lancashire Footwear Manufacturers Association. Although most of the footwear manufacturing firms in Britain belong to one or the other of these two organisations, there are a few which do not. Thus, the figures in this table may be slightly lower than if all firms were included. The employment statistics in the table refer to all employees, including administrative, technical and clerical staff.

It should be noted that a *firm* may operate more than one *factory*.

made to a standard pattern, for troops, became apparent. The first recorded order for a large quantity of footwear was placed with a group of Northampton shoemakers in 1642. This was an order for 4000 pairs of shoes and 6000 pairs of boots to supply the Royalist armies in Ireland. It probably marks the beginning of wholesale footwear production in Northampton, and perhaps in Britain. Subsequently, similar orders were placed in the town, particularly to supply Cromwell's New Model Army, the first large standing army ever to exist in Britain. Under the transport conditions of seventeenth-century England, Northampton was in a good position to establish and maintain contact with the London market. Given the initial start provided by military contracts, the master shoemakers in the town strengthened their trade links and the fact that the army clothiers needed a fairly standardised product meant that a sensible division of labour could be introduced and the scale of production increased. In Northampton itself, a number of artisans had been left unemployed by the decline of the town's formerly prosperous woollen industry and there was a surplus of agricultural labour caused by enclosures in surrounding parishes. These things, combined with supplies of good quality leather, initially from local sources, and later also from London, provided a favourable economic climate for the steady growth of wholesale footwear production in Northampton.

Stafford (1760) and Norwich (1792) are two other places where the production of footwear on a wholesale basis began fairly early. Stafford, like Northampton, had a flourishing local leather industry but perhaps just as important, at least in the early stages, was the personal friendship between William Horton, the first wholesale footwear manufacturer in the town, and R. B. Sheridan, playwright, influential at Court, and Member of Parliament for Stafford from 1780 to 1806. Through his influence in London, Sheridan obtained sizeable orders for his friend. Norwich, too, had local tanneries but the decline of the woollen industry in the city during the eighteenth century made available a large labour force skilled in manual operations, and when wholesale shoemaking was introduced by James Winter in 1792, it was quickly taken up as an alternative source of employment.

Thus, by 1800, there were three concentrations of wholesale footwear production in England, the one at Northampton being of greater importance than the others. Nevertheless, they were small. Even in 1841, Northamptonshire contained only 7000 shoemakers, barely 4 per cent of the total number in England and Wales, and the local bespoke maker still provided for the largest part of the country's population. The main reason for this was that, before the introduction of machinery, wholesale manufacture was superior to traditional bespoke methods only for the fulfilment of large military orders. However, important changes came in the nineteenth century. Particularly significant was the great increase in the population of Britain under the influence of the Industrial Revolution. This created the opportunity to market a cheap, mass-produced article suitable for the growing number of wage earners manning the factories and mines of the new industrial areas. Footwear machinery began to be introduced from 1840 onwards. It reduced the degree of skill required for all but the better qualities of footwear and reduced the advantage of the experience in the industry that had been accumulated over the years in Northampton, Stafford and Norwich. In these circumstances it was only a question of time before other areas began to develop a factory-based industry. In Northamptonshire itself, the industry rapidly spread out to several other places in the county, notably Rushden, Higham Ferrers, Kettering, Raunds, Rothwell and Wellingborough, in the search for extra labour. Perhaps even more important, however, was the entry into the industry of places elsewhere in Britain which had previously shown no signs of specialisation in wholesale footwear manufacture, notably Street in Somerset (1833); Kendal in Westmorland (1842); Bristol and Kingswood (1843); Leeds (1850); Leicester (1851); the Rossendale area of Lancashire (1876) and, in Scotland, Kilmarnock. At Street, footwear manufacture grew out of currying and the making of sheepskin rugs. Early entrepreneurs at Bristol and Kingswood were able to make use of part-time workers from the local coal mines and could draw upon a well-developed local tanning industry for their leather supplies. In Rossendale, the footwear industry grew from the habit of

workers in local felt warehouses of making up ends of felt into slippers, to avoid damaging the material over which they had to walk for the purpose of matching patterns. Leicester, with some smaller nearby towns such as Barwell and Earl Shilton, quickly became the most important of the 'new' centres of footwear manufacture. Leicester gained its start in the industry through the enterprise of Thomas Crick who, in 1853, patented a method of riveting soles and uppers together. Until this time, Leicester lacked a

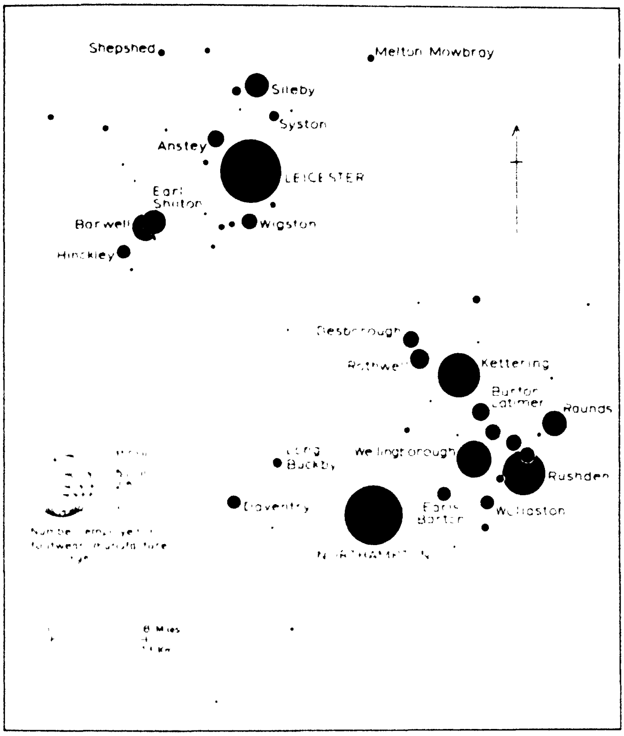



FIG. 206. The footwear industry of the East Midlands (after P. R. Mounfield)

handsewn footwear industry of any size, and this meant that machinery could be introduced more easily than in places such as Northampton, which did have a strong tradition of handsewn work. The decline of the local domestic hosiery industry in Leicestershire provided a source of suitable labour.

Thus it was in the period from approximately 1850 to 1914 that many of the existing centres of footwear manufacture in England and Wales achieved their present importance. The reasons for the location of the industry at each place tend to be slightly different, but it is notable that footwear manufacture has often provided a replacement for other formerly important local industries.

The longest period of continuous prosperity for the industry was from 1890 to 1914, when footwear exports boomed and many modest fortunes were made. However, several important overseas markets were lost during the First World War and after, when foreign countries which had formerly imported shoes from Britain began to develop their own footwear industries. The total number of boot and shoe *factories* in England and Wales fell by half between 1914 and 1955, from 1021 to 550. As for more recent years, it is clear from the table on p. 609 that, whilst production per worker and total output of footwear have increased in nearly all of the major centres of production, both the labour force and the number of *firms* have decreased in nearly every case. A striking feature has been the substitution of rubber and synthetic materials for leather as a sole material since the early 1950s.

*Employment in clothing and footwear industries, 1966 by regions* (thousands)

| | | | |
|---|---|---|---|
| North | 33 | Wales | 16 |
| Yorks. and Humber | 59 | West Midlands | 22 |
| East Midlands | 78 | Northwest | 94 |
| East Anglia | 14 | Scotland | 32 |
| Southeast | 150 | Northern Ireland | 27 |
| Southwest | 26 | Total | 551 |

## The clothing trade

Everyone must wear clothes and the industry, excluding footwear, employed 425 000 in 1968. The little dressmakers' and tailors' establishments which were so important in the past still persist in towns of almost every size up and down the country; indeed, in 1948 over 40 per cent of all the 12 000 firms in the industry employed less than ten persons each,[1] but the large-scale manufacture of articles of clothing has become concentrated in a number of distinct centres, and it is perhaps because the requirements of clothing are broadly proportional to the population that these centres are the great conurbations. It would seem that the proximity of the market is more important than local supplies of raw material, though that too is seen to exercise an important influence in a number of areas. A leading place amongst the list of centres must be given to Leeds, not only because it con-

1. There are no comparable later figures; but the Census of Production 1963 records that in the manufacture of women's and girls' tailored outerwear 678 out of a total of 1135 firms employed under 25 people; and in the manufacture of men's and boys' tailored outerwear 584 out of 1238 firms had an employment roll of under 25. There has undoubtedly been a very great reduction in the number of firms, for the 1958 Census showed a total of 1383 firms in the women's branch and 1767 in the men's branch.

tains the largest number of clothing operatives and because the variety of clothing trades carried on within its boundaries is very great, but because it is really the only large town of which clothing may be said to constitute the staple industry. The influence of the Yorkshire woollen industry is seen in the character of the clothing industry of Leeds, which specialises in outer garments of which wool is the chief material. In Lancashire, where Manchester is the principal clothing centre, dresses of light material, shirts, and underclothes are more important, obviously again indicating the importance of the local supplies of cotton and other fabrics. The Manchester industry spreads to Stockport and to Wigan, whilst that of Leeds spreads to Halifax and Huddersfield. A third centre is afforded by Birmingham, Walsall, and neighbouring towns of the Midlands. A perhaps greater geographical interest attaches to the group of clothing manufacturing towns in the west of England of which Bristol is the centre; it also includes Gloucester and the Stroud valley, Taunton and elsewhere. Doubtless the clothing firms here are a legacy of the once important cloth industry now largely disappeared. It is natural that the hosiery centres of Nottingham, Leicester, and Kettering should not cease with the manufacture of knitwear, but should include also the manufacture of underclothing of different types. In the southern and eastern counties there are many towns, such as Colchester, Norwich, Portsmouth, Basingstoke, and Reading which have individually quite important clothing industries, but it is in Greater London that the industry is really important (see Chapter 26). To a considerable extent the clothing industries are 'footloose' and can be located wherever suitable labour can be recruited and a local market exists. Portsmouth with its corset factories employing mainly women is an interesting example of a deliberate attempt to use available labour: here the dockyard employs almost exclusively male labour. Luton, in Bedfordshire, was the chief centre in Britain for the manufacture of hat shapes, an interesting later development of the former domestic industry in straw plaiting and weaving which in turn was the result of a situation in the midst of a rich cereal-growing country.[1] In Scotland there is really only one important clothing centre—Glasgow.

Glove manufacture is a specialised branch of the clothing industry, linked, however, not with the main clothing industry but rather with the present or former production of fine leather and with the West Country textile industry. Small towns in Worcestershire, Wiltshire, Dorset, and Oxfordshire contain much of the industry (nearly 40 per cent of the 10 700 employees in 1948 were in the South-West Region), which in part arose out of the declining woollen trades (cf. p. 501), and was accompanied, as noted above (p. 607), by the development of small-scale tanneries for the local sheepskins which are still largely used.

1. See C. M. Law and D. J. M. Hooson, 'The straw-plait and straw-hat industries of the South Midlands', *E. Midland Geog.*, **4**, 1968, 329–50.

## Food industries

Naturally, if one includes bakers, workers in the preparation of foodstuffs are very widespread throughout the country. A map of the distribution of bakers and flour confectioners would show the same pattern as a population map, and some of the other food industries are also located mainly in the major urban centres, with the London area dominant almost throughout, but in some cases other geographical or economic factors may be involved.

*Employment in food, drink and tobacco industries, 1966* (thousands)

| | | | |
|---|---|---|---|
| Bread and flour confectionery | 159 | Cocoa and chocolate | 95 |
| Grain milling | 43 | Sugar refining | 16 |
| Biscuits | 51 | Brewing and malting | 96 |
| Bacon, meat and fish products | 88 | Other drinks | 69 |
| Fruit and vegetable products | 73 | Tobacco | 50 |
| Milk products | 41 | Total | 850 |

*Employment in food, drink and tobacco industries, 1966, by regions* (thousands)

| | | | |
|---|---|---|---|
| North | 34 | Wales | 22 |
| Yorks. and Humber | 81 | West Midlands | 72 |
| East Midlands | 46 | Northwest | 126 |
| East Anglia | 39 | Scotland | 99 |
| Southeast | 229 | Northern Ireland | 30 |
| Southwest | 63 | Total | 841 |

*Bread and flour confectionery* occupies 20 per cent of the total employed and is the most widely distributed, but London has a quarter of the total. Even there the universal tendency towards larger units is seen. The same is true of *brewing and malting* (11 per cent of employees) and the *soft-drink* industry (5 per cent). *Milk products* (5 per cent) are made in the country districts still (only a seventh of the employees in London and the southeast). More localised are *biscuit making* (6 per cent), *cocoa and chocolate* (11 per cent), *sausages and preserved meats*.

We may perhaps distinguish three types of location: (*a*) The larger towns, where industries may exist, based originally on local agricultural produce and often still in part dependent thereon—e.g. mustard at Norwich. In some cases perhaps a local traditional occupation has affected the establishment of allied factory industries, and Reading's biscuit manu-

facture may be an example of this. Certainly the fruit and vegetable preserving industries of such places as Peterborough, Wisbech, and Dundee come into this category. Rather different in character is the milk products industry which, though sometimes located in the market towns, is more commonly completely rural in location, depending upon good rail and road transport. The importance of the Northwestern Region (which includes the Cheshire Plain), and of Southwest England in this industry is clear from what has been said (pp. 197–9). (*b*) Certain types of food processing are naturally concentrated on the great ports where the imports (e.g. grain and sugar) arrive. Large-scale grain milling in particular tends to be concentrated at ports, notably Liverpool, London, Bristol, Hull, Southampton, and Manchester (though there are, of course, many inland flour mills, mainly served by rail or inland waterway). So does sugar refining, in which London and Liverpool again lead; and the manufacture of margarine (from imported fats) is another example. (*c*) Food industries, like many other partly 'footloose' industries, often exist in localities which have been chosen for essentially non-geographical reasons—e.g. the chocolate industries of Bournville (near Birmingham), and York. And food processing being often a 'light industry', there are numerous examples of twentieth-century factories on the periphery of the great conurbations, or in trading estates, or more recently in the Development Areas. Thus half the country's output of baked beans is produced at Wigan, in what is in fact the largest food-processing plant in the Commonwealth.

## Paper

The manufacture of paper and cardboard is a widely distributed industry, and has been so ever since it began in the late fifteenth century. Formerly rags and abundant clear water were the main necessities; at the end of the eighteenth century there were over 500 small paper mills in the British Isles, all manually operated. Then water power and bleaching chemicals became of importance and by about 1860, straw, mechanically formed wood pulp, chemical pulp and esparto grass had entered the field, largely to supplant the use of rags. Mills increased in size and decreased in number; by 1900 there were only 280, and the process of eliminating the smaller rural mills and concentrating on larger establishments has continued, so that the total in 1948 was about 228 mills distributed as shown on p. 616. Water supply is still a major factor, since very large quantities (amounting to millions of gallons a day) are required by the mills; but facilities for the disposal of the effluent are almost of equal importance (compare the artificial silk industry, p. 591). Soft water is desirable in general (and is always an asset where steam-driven plant is employed) but purity and freedom from colouring matter (particularly iron) are more important; hard water is not objectionable in the newsprint branch of the industry, since chalk is in any case often used as a filler for the paper.

The regional distribution of the paper industry (cf. employment table on p. 601) is as follows:

| AREA | NO. OF MILLS |
|---|---|
| Lancashire (and adjacent parts of Cheshire and Derbyshire) | 38 |
| Kent | 32 |
| SW England (Gloucester, Somerset, Devon) | 22 |
| Yorkshire | 16 |
| Chilterns (Bucks, Herts) | 12 |
| East Scotland (Fife, Stirling, Clackmannan) | 14 |
| Midlothian | 13 |
| West Scotland (Lanark, Renfrew) | 10 |
| Aberdeen | 6 |
| Other areas | 65 |
| Total | 228 |

The annual output of paper and board in recent years has been steadily rising. Average for 1956–60: Newsprint, 666 000 tons; Other paper and board, 2 911 300 tons, Total, 3 577 300 metric tons. As production has risen, so the tendency has been for a concentration in larger units

Two of the most important regions in the industry are the fringes of the Mid-Pennines and North Kent. In Lancashire and Yorkshire, pure water from the Millstone Grit, early water power possibilities, later the ready availability of coal and chemicals and an abundant supply of cotton rags from the local textile industry, and then the proximity of the Mersey, Ribble, and Humber ports for the import of wood pulp and exports contributed to the rise and persistence of paper manufacture, while the large local population provides not only a market for the output but also a source of waste paper and rags as further raw materials.[1] In the case of North Kent (Dartford–Gravesend and the Maidstone–Medway area) where a large proportion of the newsprint industry is concentrated, large water supplies from the Chalk, and river frontages for the disposal of effluent and the import of fuel and raw materials, together with the proximity of the enormous London market, have been the major factors involved.

There are many inland centres of paper-making, many of them of long standing and often highly specialised—e.g. banknote paper on the flanks of the Mendips, near Wells, fine writing paper and blotting paper at various mills in the Chilterns (e.g. Apsley, Loudwater); fine transfer paper for the pottery industry at Cheddleton, near Leek; and highly specialised packaging paper for the food industry, at Watchet, in Somerset.

In Scotland, paper-making also has a long history and a wide distribution. The Edinburgh district produces upwards of three-quarters of all the

1. In Radcliffe, for example, 2000 out of a total working population of 16 000 are employed in the paper industry (which is more important than textiles), and in Bury, paper employs 3500 out of a total working population of 30 000.

esparto paper in the country, and has long been famed for the variety and high quality of its products—which are much used locally in the stationery and printing trades, as well as having worldwide markets. Glasgow is the main newsprint centre, Aberdeen has several mills, and there are numerous other centres, mostly on the eastern side of the Central Lowlands, and mostly specialising in particular varieties of paper products.

An allied industry is the conversion of paper and board into products for the use of other industries. There are actually more paper-converting mills than paper-making mills; many of them are in the same areas as the paper mills, but there are also very many in the Midlands where are located so many manufacturing industries needing boxes, wrappings, cardboard tubes, and so on for the marketing of their products.

## Printing and bookbinding

Of the workers enumerated in Great Britain, approximately one-third are located in the London area. Further, many printing firms have, for reasons of economy, migrated to towns which, although accessible from the metropolis, are outside it. Thus, this book is printed at Beccles, in Suffolk. Other well-known firms have chosen locations such as Colchester, Guildford, Maidstone, and Rochester. There is also still an interesting association between the printing, bookbinding, and publishing trades and the great centres of learning. One may cite particularly Edinburgh in the case of Scotland, and Oxford in the case of England.

## The furniture industry[1]

Although furniture-making is widespread there are significant concentrations of the industry. Measured by the percentage of total value of manufacturers' turnover, the chief producing areas of Britain in 1957 were London and southeastern (45.3), southern (15.1, of which High Wycombe accounted for 12.0), and northwestern (11.4). In 1956 London led in cabinet and upholstered furniture (respectively 52.6 and 34.4 per cent of Britain), south in chairs (41.4, though the making of chair parts in the Chiltern beechwoods ceased in 1960).

In Greater London the Shoreditch and Bethnal Green district remains the home of small manufacturers and of manufacturers' suppliers, but most furniture is now made in a belt along the River Lea, from Bow through Lea Bridge (Leyton), Walthamstow, Tottenham, Edmonton and Enfield. Large quantities of timber are brought by lorry and barge from the Port of London to Lea-side merchants' and manufacturers' premises. New centres are developing with easy access to main roads, as at Barnet, Watford, and

1. See J. L. Oliver, *Development and Structure of the Furniture Industry*, Pergamon Press, 1966.

Letchworth, all near the A1 or M1 roads, and as at Romford, Brentwood, and Southend on the Southend Road or within short distances from it.

In the concentration of the furniture industry on the capital London follows the pattern of Copenhagen, Oslo, Stockholm, Vienna, and Paris. In very few towns in the world does furniture-making dominate local economic activity. High Wycombe, Buckinghamshire, is almost unique in this respect.

## The rubber industry

Although Hancock set up a factory in London in 1819 to process raw rubber and later collaborated with Mackintosh, the inventor of waterproof garments, the rubber industry may be quoted as an example of an industry of comparatively recent origin—Dunlop invented the pneumatic tyre in 1888—which illustrates the varying strength of factors determining location. The raw material is, of course, of equatorial or tropical origin, and must be imported. One would therefore expect the industry to be concentrated near the great ports. On the other hand the question of market arises. A large proportion of the rubber is required for tyres for the motor industry, and in connection with the electrical industries which have become established particularly in south Lancashire and the west Midlands, where rather over half the workers in the rubber industry are located. Avon tyres at Melksham, Michelin at Stoke, Goodyear at Wolverhampton each suggest interesting studies in industrial location.

## Tourism

This somewhat inappropriate term is coming to be widely used for what, some claim, is now the world's most important industry. Alternatively we may refer to the 'holiday industry'. In the past holidays with pay were enjoyed by only a minority of the population and holiday for the majority consisted of short trips arranged actually on statutory bank holidays, especially the first Monday in August. It is now true to say that the majority of jobs in Britain include two or three weeks' holiday per year during which normal rates of wages or salary are paid. In 1962 over 4 million Britons out of a total population of some 50 million left the country to holiday on the continent. Figures for tourists or holiday-makers thus going abroad are known with considerable accuracy but it is much more difficult to assess the importance of tourism at home. Sample surveys suggest that 80 per cent—let us say 40 million—leave their homes for a holiday of some sort during the year. But there are 10 816 000 private cars and 1 324 440 motor cycles registered in Britain (1968) costing to run 7*d* out of every £1 earned (1962). The huge mileage of non-business journeys, with the cost of meals taken

en route, in reality is all part of the great business of tourism, the full extent of which it is impossible to measure.

The attraction of visitors and catering for their varied needs have become the major preoccupation of many local authorities. One method of assessing the importance of the traffic is by accommodation available. We may use the number of beds available but since many hotels are open for the summer season only a better measure is bed-nights, and this is the best available measure of the use made of accommodation. Caravan and dormobile users escape this census however. The average cost of a bed-night gives some measure of money which changes hands either for accommodation alone or on a bed and breakfast basis. Since, however, most families set aside a more or less definite amount for holidays we have another measure. At £10 per head £400 million would change hands in this country, at £25 the total rises to £1000m. In the mid-fifties (traffic has been increasing since) it was shown that summer visitors brought into and spent more money in the county of Devon than was represented by the total output of agriculture in that large and rich farming county. The £15m per annum spent by visitors to the Channel Isles is the major source of revenue.

It follows that a high economic importance attaches to the possession of what tourists want or the amenities to be provided for them. It has been calculated that over 40 per cent of all recreation is 'water based', on the sea or inland waters, and that, as in America, a boat on some lake (probably a reservoir) or sheltered estuary has become a 'status symbol', probably taking precedence of a second car. A country or seaside cottage is now within reach of many and the demand for such solves one problem but creates another. As agriculture becomes more efficient and more fully mechanised, a smaller labour force is needed to maintain or even increase production from the land. There is rural depopulation and cottages formerly occupied by agricultural workers become redundant, as do a proportion of farmhouses. Provided the area is scenically attractive and the cottages are fundamentally sound in construction, they become occupied by townsfolk, first for weekends or summer use and later for retirement. This 'adventitious' rural population (p. 659) brings both manpower needed to sustain the social structure of the village or countryside and a certain amount of money earned outside. A problem is however created when demand for cottages exceeds supply and the adventitious townsman outbids the rural worker, or when the demand is such that extensive building upsets the balance and agricultural land is threatened.

An allied problem is provided by the caravan. It was estimated in 1968 that about 5.5 million people, or one-seventh of all British holiday-makers, now take their holidays in a caravan, usually rented for a short period at one of the 5000 licensed sites that are now to be found round our coasts and at inland localities where scenery or the presence of water (lakes or rivers) provide the attraction. Nearly sixty of these sites have places for over 500 caravans, and the three largest—at Porthcawl in South Wales, at Selsey

near Portsmouth and at Canvey Island on the Thames estuary—each have space for over 1500 caravans.[1] Many a delectable piece of coastal scenery has been marred by caravan sites—but clearly this is a form of holiday that is much appreciated by large numbers of people; and of course the rent from the sites provides a useful source of income for farmers and landowners.

The establishment of National Parks and Nature Reserves has already been discussed (pp. 132–3). In Scotland chair-lifts have been constructed in the Cairngorms to encourage winter sports: they are equally popular with summer tourists.

The development of resort towns is far older. The Romans were quick to appreciate the curative value of hot mineral springs—as seen in Bath (and inland watering places where the sick sought to drink the waters), which enjoyed a fluctuating fortune for many centuries. In the eighteenth century they began to share with the new type of watering places—those by the sea—a prosperity associated with Royal and noble patronage. In particular the Prince Regent, afterwards George IV (1820–30), made Brighton, where he built the fabulous oriental-style Brighton Pavilion (now carefully preserved by the Corporation) in 1784. Other members of the royal family are associated with the rise of Weymouth (Duke of Clarence), and as the development of railways facilitated access 'watering places' grew up in many places round the coast, inland spas—either new or resuscitated—grew up at places like Buxton, Matlock, Harrogate, Leamington, Cheltenham, Tunbridge Wells, and even as far afield as Strathpeffer beyond Inverness. The pattern of Victorian and Edwardian life for the wealthier included some weeks *en famille* by the sea, often at old fishing ports which assumed new functions and gained new features—such as Whitby, Scarborough, Cromer, Sheringham, Felixstowe, Margate, Ramsgate, Hastings, Eastbourne, Torquay, Brixham, Penzance, Newquay, Ifracombe, Aberystwyth, and many others. These are apart from other seaside resorts, exemplified by Blackpool and Southport, which grew up as such (p. 702).

Another aspect of tourism is the attraction to Britain of foreign visitors, who in 1968 numbered over 4 million (compared with 1.8 million in 1961). These tourists spent some £274m in Britain, and their fares paid to British shipping, airlines and railways brought the total income to £375m—which compares with the estimate of £272m spent on foreign travel (including business visits as well as holidays) by United Kingdom residents. Tourism thus has an important part to play in helping to solve the nation's balance of payments problems.

One of the greatest attractions for foreign visitors is undoubtedly London, with its wealth of historic buildings and its array of cultural facilities. But for many, including the Americans who come in large numbers and who have ancestral roots in Britain and claim our cultural heritage as their own, the interest is primarily in the historic towns and cities—the cathedral

1. *Caravan Sites 1969*, published by *Modern Caravan*.

cities of Canterbury and York, the castles of Edinburgh and Caernarvon, the colleges of Oxford and Cambridge, and of course Stratford-on-Avon. The 'stately homes' in the countryside, especially those with gardens, and many now owned by the National Trust, are another attraction. Overseas visitors also look for the best of British scenery—the Highlands, the Lakes, Devon and Cornwall—but boating and bathing they can probably enjoy better at home.

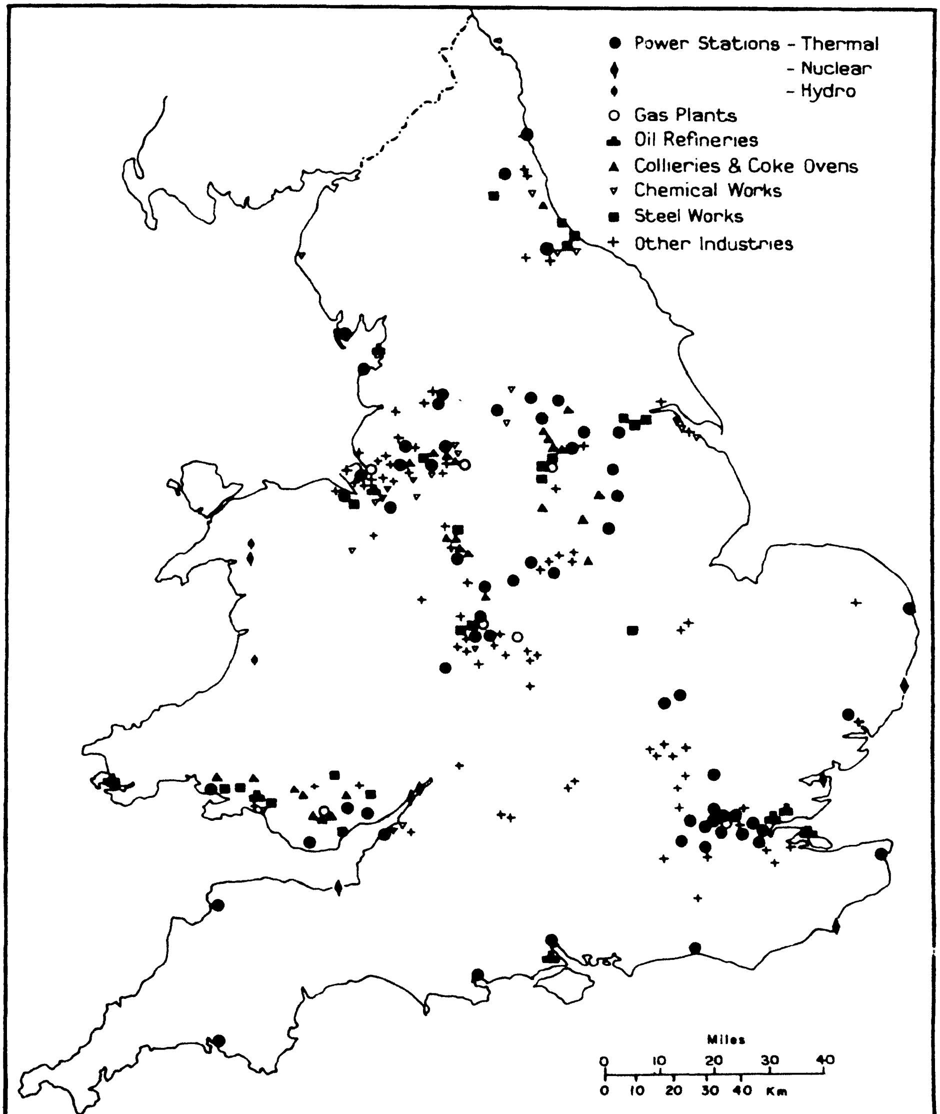



FIG. 207. The location of new factories and power plants, 1945–61

The increase in tourism of all kinds has brought new pressures on the countryside and has enhanced the importance of intelligent conservation. The desire to see and enjoy the amenities of the natural scene encourages the provision of the very facilities—motor roads, caravan camps, hotel and motel accommodation—that are capable, without the most careful planning, of destroying those same amenities.

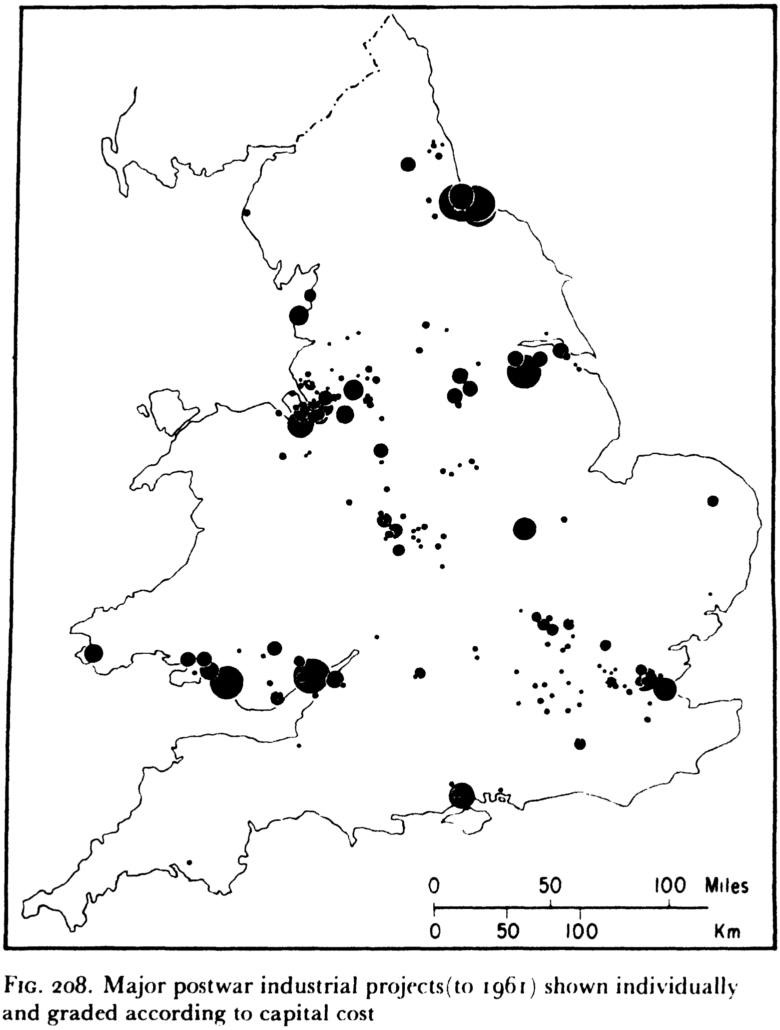



FIG. 208. Major postwar industrial projects (to 1961) shown individually and graded according to capital cost

Certain major features are readily recognisable: (*a*) steelworks projects (e.g. Scunthorpe, Middlesbrough, Newport, Port Talbot, Corby, Consett, Shotton); (*b*) chemical projects (e.g. Wilton (Tees-side), Severnside); (*c*) oil refineries (e.g. Milford Haven, Fawley). Despite the emphasis on capital-intensive developments in the peripheral 'Development Areas' of South Wales and the northeast, the continued dominance of the 'axial belt' from Thames to Mersey is still evident

## Postwar industrial development in general

The interwar years were marked by the contrast between the decline, with accompanying unemployment, of the old outer industrial areas—mid-Scotland, Tyneside, West Cumberland, and South Wales in particular—

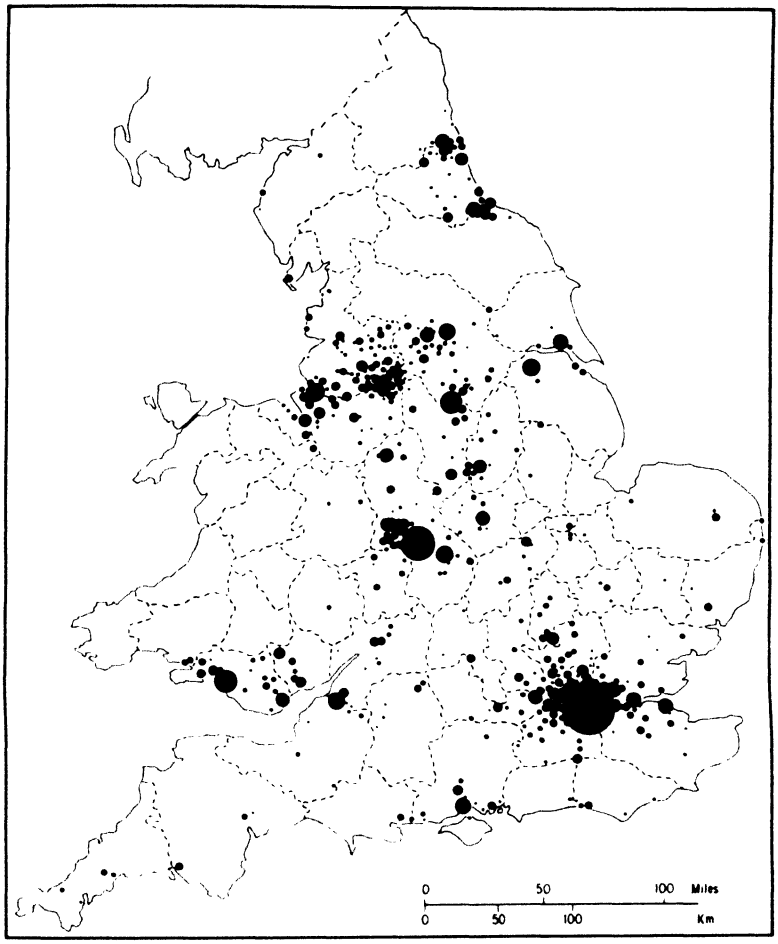



Fig. 209. The rateable value of industry, 1961, showing concentration on Greater London, Birmingham and Lancashire–Yorkshire

on the one hand and the expansion and prosperity of the two great industrial regions of Greater London and the West Midlands on the other. The decline in the old cotton area of Lancashire was balanced by the growth of new industries in the Liverpool–Ship Canal–Manchester area. Worried by this growing unbalance the government of the day set up the Royal Commission on the Geographical Location of the Industrial Population under the chair-

manship of Sir Montague Barlow and the resulting Barlow Report, issued shortly after the outbreak of the Second World War, advocated a planned dispersal of industry.

A rapid dispersal of industry quickly took place on the outbreak of war for other reasons—to avoid the concentration of war-material factories in vulnerable easily bombed concentrated sites.

The government realised that the dispersal of industry, whether deliberately planned or necessitated by wartime conditions, would profoundly affect life in what had previously been purely rural areas and set up the Committee on Land Utilisation in Rural Areas under Lord Justice Scott. The Scott Report took a broad view and in implementing its recommendations the government in due course introduced the Agriculture Act, 1947 which stabilised farming by giving farmers a guaranteed market and guaranteed prices, and the Town Planning Act, 1947 which made the preparations of plans for future development, on a county and county borough basis, compulsory over the whole country. There followed also the National Parks Act, 1949 which set up a National Parks authority and also the Nature Conservancy (see pp. 132–3 and Fig. 77). In the postwar period it has been the policy of successive governments (*a*) to encourage new industrial development in the older industrial areas, (*b*) to secure some dispersal of population by building new towns (Fig. 77) and (*c*) to discourage—not very successfully—the further growth of London and Birmingham in part by restricting licences for factory building, in part by laying down 'green belts' in which any building or other development would be strictly curtailed. Three maps, prepared by Dr E. C. Willatts, show the results on industrial development of these various government measures.[1] The first, Fig. 207, shows the location of new factories and power plants (1945–61) each costing more than £5m. This map should be read together with that showing new towns (Fig. 77) and the Electricity Grid map (Fig. 152). The same facts are shown differently in Fig. 208 where no distinction is made between the different industries. Finally Fig. 209 shows that the new developments, important though they are, have not changed the supremacy of the great industrial centres of London and Birmingham.

1. E. C. Willatts, 'Post-war development: the location of major projects in England and Wales', *Chartered Surveyor*, 1962, 356–63.

# 24
# The peopling of the British Isles

Two sets of factors may be said to have exercised a dominating influence on the early peopling of the British Isles. The first set of factors is climatic, the second is physiographic. There is no doubt that there were human inhabitants in the British Isles before, or at least in the earliest stages of, the great Ice Age. As glacial conditions spread southwards so man was forced to retreat before the advancing cold, and River Drift or Paleolithic man left the open valley bottoms and took refuge in caves. But it is clearly incorrect to picture a continuous southward spread of glacial conditions and then a continuous northward retreat. Periods of intense glaciation were succeeded by comparatively warm interglacial periods which in turn were terminated by a renewed onset of colder conditions. The extremely difficult, if fascinating, work of correlating the glacial and interglacial deposits of this country and of tracing their connection with the movements of early man is one which has for long periods unceasingly occupied the attention of both geologists and archaeologists. If we consider the period of maximum extension of glaciation we may rightly picture the whole of Ireland and the whole of northern Britain, as far as a line joining the mouth of the Thames and the mouth of the Severn, as being covered by ice sheets of greater or less extent and of varied origin (see Fig. 14). At this period the extreme south of Britain, therefore, would be occupied by land comparable in climatic and probably in vegetational characteristics with the great Tundra lands of the present day. On these Tundras or Arctic grasslands the reindeer, amongst other animals, flourished, and attracted the attention of early man, the hunter. When the ice sheets finally retreated these Tundra grassland conditions moved gradually northwards and probably man, still the hunter, went with them. The place of the Tundra in Britain was then gradually taken by forests. In recent years, especially as the result of the work of Prof. H. Godwin, precision has been given to the determination of climatic fluctuations during and since the Ice Age by the analysis of pollen grains found in the successive layers of peat deposits. Tundra conditions were succeeded by forests in which coniferous trees predominated while milder conditions were marked by an influx of deciduous trees. After several climatic cycles, the establishment of a mild, moist climate resulted in the general spread over the lowlands of the deciduous forests which form the characteristic natural

vegetation of these islands at the present day.[1] The spread of forest increased the difficulty of sustaining life from the spoils of the chase, and so encouraged the settlement of man in more open areas on the uplands and along the coast. The coast dwellers apparently obtained shell fish, and their implements are of 'Tardenoisian' type. Later came the introduction of primitive agricultural and domestic animals, probably by invaders who were forerunners of the Megalithic and Beaker peoples. With the development of a more settled life there was no longer the necessity to be continually on the move, and several writers have properly stressed the importance of the change, especially on child life. No longer was it necessary for the children to be carried about continuously on their mothers' backs. Infant mortality lessened, and there was an increase in the population, and with the increase an improvement in moral and physical conditions. It must be remembered that simultaneously the great vegetation belts of the world which we know at the present day must have moved northwards, and this northward movement of environmental conditions with which they were familiar in itself encouraged the northward movement of peoples. This invited naturally a migration into, and a settlement of, Britain from the Continent.

The main physical features of the British Isles profoundly affected the lines of movement both of traders and of settlers. Prehistoric immigrants who entered Britain from the south or from the east spread westwards and northwards, though avoiding the thickly forested clay lowlands and using as their avenues of movement, for the most part, the more open hill belts. Their movements were stopped, or at least hindered, by the hilly barriers afforded by the Pennines, the edge of the Welsh massif, and the hills of Devon and Cornwall. It might be thought that they would penetrate through what is now called the Midland Gate into the plain of Cheshire and Lancashire and thus reached the Irish Sea, but it would seem that that lowland was covered by a very heavy growth of damp forest which prevented access to the western seaboard. Later, it is clear that during the Roman period the settlements of the Romano-British population were in the main limited[2] to the 'lowland zone', and it is still clearer when one comes to the succeeding period and considers the distribution of Anglo-Saxon settlements. On the other hand there was the stream of traders and settlers who approached the British Isles by the seaway from the west and southwest. It is clear that, though they were able to spread over the whole of Ireland, their colonies were largely restricted to the coastlands of Devon, Cornwall, the Scillies, Wales (especially Glamorgan, Pembrokeshire, Caernarvonshire and Anglesey), the Isle of Man, the Western Isles and adjacent coasts of Scotland, Orkney, Shetland, the plain of Caithness and

1. For a short summary see Chapter 14 of L. D. Stamp's *Britain's Structure and Scenery*, Collins, 1946; also above, pp. 86–7, and p. 118.

2. Later work, especially by O. G. S. Crawford, has demonstrated the considerable extension of Roman control and influence into southern Scotland.

the shores of the Moray Firth. Only when they had overcome the intervening mountain barriers – and still more the forest and marsh barriers—were they able to descend on, or mingle with, the people of the lowlands to the east. It was not apparently till a much later stage, that of the Scandinavian invasions, that a movement of people coastwise from the north of Britain became important.

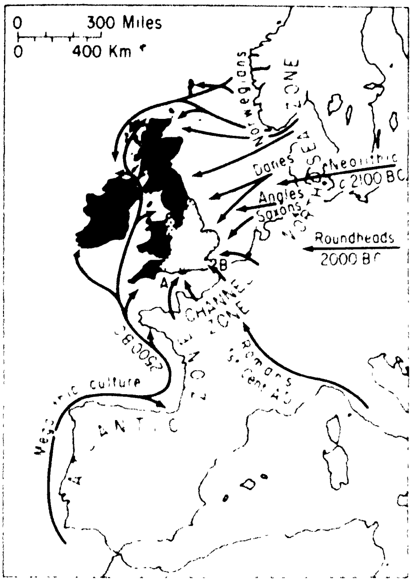



FIG. 210. The routes from Europe into Britain followed by early traders and invaders

The 'highland zone' is shown in black, the 'lowland zone' by dots. A and B – routes followed by invaders and traders of the late Bronze Age; B – routes followed by Romans

There is, thus, in the peopling of Britain a fundamental distinction to be made between the lowland zone of the south and east and the highland zone of the north and west. Already, before the dawn of written history, a frontier region of peoples and cultures came into existence between the two. The dividing line between the zones corresponds roughly with the outcrop of the youngest Paleozoic rocks – the boundary between Highland Britain and Lowland Britain already discussed in Chapter 3. It would seem that the distinction between the two zones has been preserved for several reasons. Amongst them two stand out. One is that until the extensive clearance of forests in the lowland zone the habitable regions were mainly those raised some distance above sea-level, forming islands of habitable or cultivable land in a sea of forest, and where those more readily cultivable regions reached the coast there grew up the trading centres. By way of contrast the

cultivable or habitable regions amongst the hills of Scotland or Wales were the valley regions, which may be described as islands of inhabitable country within a sea of comparatively useless hills. In the second place the lowland zone is that neighbouring to, and easily accessible from, the Continent, and so successive waves of invaders came in and imposed their culture, and often their racial characteristics, on the existing inhabitants. On the other hand, in the highland zone, such of the few invaders as penetrated into the valleys tended to be absorbed by the existing population. This is important, because it helps to explain the persistence of differences between the Highland Scot or the Welshman on the one hand, and the English lowlander on the other.

Professor H. J. Fleure presented a summary of the main results of research before 1920 on the pre-Roman peopling of the British Isles in *The Races of England and Wales* (1923).[1] Later a particularly interesting and well illustrated summary was drawn up by Sir Cyril Fox,[2] who shows how after the final retreat of the ice, but earlier than 2000 B.C., a powerful Megalithic civilisation spread over the whole of Ireland and the highland zone of Britain, including the plateau of Caithness and the lowlands round the Moray Firth. The culture had been brought by sea from the south and west, that is from Spain and Atlantic France. The invaders were the builders of the dolmens and other huge stone monuments which are still found widely distributed in Ireland. In Britain they evidently pressed eastwards, and the stone circles of Stonehenge and Avebury are evidence of the importance of their dominance in the Salisbury Plain region. Forty of the lesser stones of Stonehenge were actually transported from Pembrokeshire. The builders of the great stone monuments seem to have been long-headed people, probably of short stature and dark skin, and the evidence points to them as the oldest large element in our population. They buried their dead in long barrows, and hence they are sometimes known as 'long barrow' people.[3] Simultaneously the east of Britain seems to have been strongly influenced by a Neolithic culture of peoples coming from the east, from the Baltic region, or possibly from farther eastwards from the Kiev region or from Upper Silesia, passing on their way to Britain through Denmark and Holland. In Britain, the remains of these people, often known as the 'Beaker' people as they are associated with rough pottery of curious form known as beaker pots, are left most characteristically along the east coast from Caithness to the Humber, and in the southeast, where they evidently penetrated along the chalk ridges. The earliest arrivals brought no metal, but copper and bronze daggers were a little later commonly buried with the dead. They buried their dead in round barrows. Burials of the succeeding stage

1. In 1951 Professor Fleure summarised his long life's work in this field in *A Natural History of Man in Britain*.

2. *The Personality of Britain* (see Bibliography, p. 829).

3. Some authorities regard the long barrows as a variety of megalith belonging to a zone farther east than the true megalith and of doubtful cultural derivation.

were also in round barrows, but usually in cinerary urns, since by that time the corpses were generally burnt. The Beaker people were short-headed people, thus allied in character to the Alpine race of the Continent of Europe or perhaps a Nordic–Alpine cross, whereas the Megalithic people may be said to be allied to the Mediterranean races of Europe.

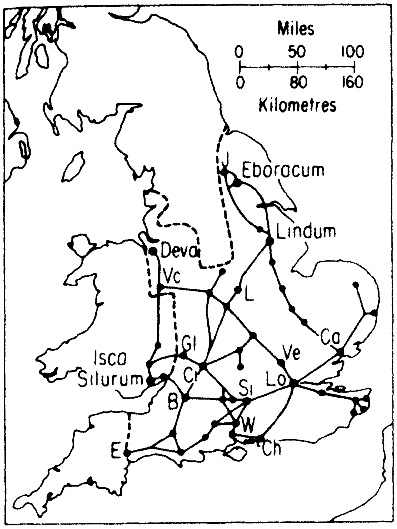



FIG. 211. The civil districts of Roman Britain (after Haverfield and Macdonald)

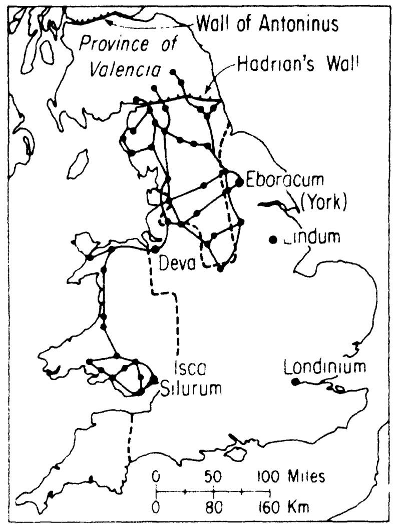



FIG. 212. The military districts of Roman Britain (after Haverfield and Macdonald)

The chief Roman roads connecting (Fig. 211) the civil settlements and (Fig. 212) the military posts

For the next stage in the peopling of Britain Fox gives the provisional date of about 2000 B.C. The invaders were from the east, the Nordic–Alpine roundheads (predominantly but not exclusively roundheaded) who came and occupied the whole of the lowland zone and penetrated far into the highland zone. They made Salisbury Plain an important centre and assimilated some of the Megalithic traditions and possibly reconstructed Stonehenge. The trade from the southwest also developed at this time and the Hampshire 'Gate' seems to have been used for the importation of bronze tools which were taken *via* Salisbury Plain to the Midlands and possibly through the Bala cleft into Wales. Many of the people of the southeastern lowlands, however, were too poor at the time to acquire these imported tools. Almost contemporary with this, Fox says, a new source of copper and bronze tools was opened up in Ireland, and these Irish products were traded in both highland and lowland Britain. There was at this time an important trade in Irish gold (obtained in the Wicklow Mountains) to the Continent, and this trade seems to have been captured by the lowland people of Britain.

By 1000 B.C. (in the late Bronze Age) there was marked activity in trading. New invaders brought with them a high culture, and developed metallurgy, particularly the art of bronze working, in Britain itself. They entered the country by the east and south coast estuaries and seem to have been most active in the Thames Basin—the middle and lower Thames valley. Here during the last five centuries B.C. the Bronze Age gave place to the Iron Age, and close contact developed between the iron-sword makers of

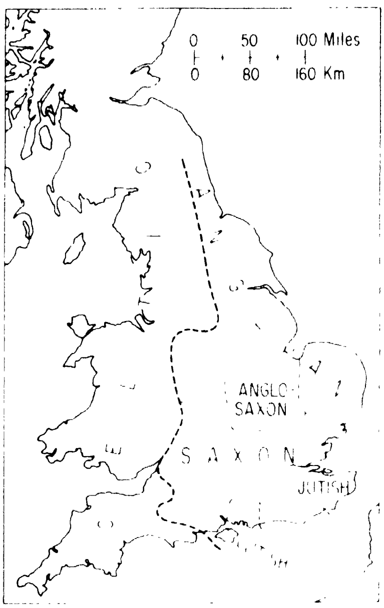



FIG. 213. Cultural zones of the Angles, Saxons and Jutes in Britain *c.* A.D. 550 (after E. T. Leeds)

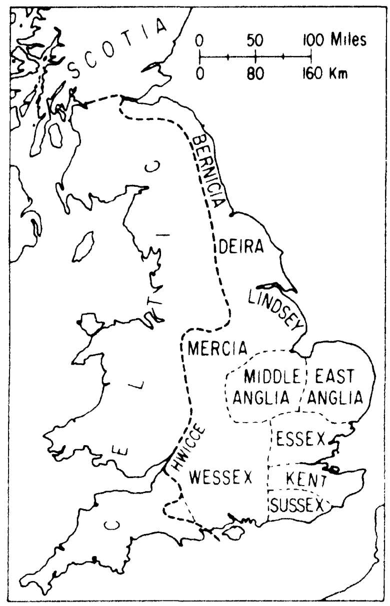



FIG. 214. Anglo-Saxon Britain at the end of the sixth century A.D., showing the kingdoms. Notice the significance of the Forth as a barrier (after E. T. Leeds)

south-eastern England (Iron Age 'A' culture) and the neighbouring parts of the Continent, with the result that the southeast had a cultural pre-eminence, and strong British kingdoms had their capitals at St Albans and Colchester. At the same time there seems to have been an important cultural centre (Iron Age 'B' culture) in the southwest, probably connected with the exploitation of Cornish tin, and the consequent stimulation of the old sea routes to the southwest.[1]

In A.D. 43 the Roman conquest of Britain began by an entry in the southeast and an advance northwestwards towards the Thames. A Roman commercial centre was quickly established at London, and a uniform control

1. Much information is now available on the Ordnance Survey Map of Southern Britain in the Iron Age, with descriptive text, 1962.

was imposed on the lowlands. Two maps are given here to illustrate the Roman occupation of Britain. The first shows the area with civil settlements in Roman Britain, and the remarkable way in which the civil districts correspond to what has been described in this work as the 'lowland zone' will be noticed at once. The Romans established cities and farms (*villae*), and made their long straight roads all over the lowland zone. In the highland zone they established military camps and military districts, but not Romanised civil settlements, though roads were extended from the lowlands into the highlands. This is shown very clearly in the second map. The distribution of Roman villas in the country—almost restricted to the lowland zone—illustrates once again the significance of the division between these two fundamental parts of Britain. After some four centuries of occupation, the breaking up of the Roman Empire resulted in the withdrawal of all Romans from Britain.

In the fifth and sixth centuries A.D. history repeated itself. This was the period of the invasions, conquest and colonisation of the British lowlands by the Angles and Saxons. The maps, Figs 213, 214, show clearly how the political and cultural division of England in the sixth century A.D. illustrate once more the contrast between the Lowland Zone and the Highland Zone; the Lowland Zone predominantly Anglo-Saxon, the Highland Zone remaining Celtic. Thus, since the Anglo-Saxons were pagans at first, the Celtic Christian Church was cut off from the Roman Christian Church of the Continent. Many of the earlier writers on the early history of Britain fell into the error of thinking that all invasions of Britain—cultural and military—had come from the east, and that each invasion in turn had pushed the earlier peoples into the highland fastnesses of Scotland and Wales, and into the outpost of Ireland. We have seen that this is fundamentally wrong;and it can again be proved so during the fourth, fifth and sixth centuries A.D. when there was extensive colonisation from Ireland of the western coasts of Scotland (where the Scots from Ireland drove out the native Picts in Argyllshire), Wales, the southwestern peninsula and Brittany; and it was indeed the coming of these Irish to western Britain that spread alarm in the waning years of Roman rule. The Anglo-Saxon colonisation largely 'fixed' the settlements of at least the lowland zone and the process was later extended.

It was in the ninth and tenth centuries A.D. that a new movement of invasion and colonisation occurred which had a lasting influence on parts of Britain. This was the invasion of Vikings or Norse and Danes which was mainly from the northeast. The Norse colonised the Shetlands and Orkneys, and a broad coastal fringe of northern Scotland, including most of Caithness.[1] The Danes colonised many places, as the distribution of place names

1. The Viking invasions so weakened the Picts of Scotland that they were conquered with ease by the Scots under Kenneth MacAlpine, who thus became the ruler of the united Picts and Scots.

shows, in eastern Britain, tending to remain on the whole along the coast, though spreading far inland along the valleys of navigable rivers. The name Danelaw is given to those districts of northeast and eastern England conquered by the Danes in the ninth and tenth centuries and in which Danish customary law prevailed. The stand made by King Alfred prevented the Danes from engulfing Wessex and between 880 and 890 a line running northwest from the River Lea roughly along the line of Watling Street was agreed as the western limit of the Danish domains, but by 920 the Danes


FIG. 215. The Norse settlements of the ninth and tenth centuries

were conquered. Another stream of Norse invaders had passed down the western coast of Scotland, colonising at intervals as they went, and forming a broad area of settlement in what is now the Lake District, the Isle of Man, and Lancashire. They showed themselves adept at recognising the more important ports of entry into Ireland, colonising round Dublin, Waterford, Cork and Limerick. In the meantime, it should be noticed, the Anglo-Saxons had penetrated farther northwards and had colonised the east of the Midland Valley of Scotland as far north as the Forth, where Lothian

formed the northern part of the Kingdom of Bernicia.[1] Thus we see the British Isles at the time of the Norman Conquest in 1066 with an Anglo-Saxon or Lowland Zone, a Celtic-speaking Highland Zone, with important Scandinavian infiltrations in the north and west. The Romans had imposed their rule and to some degree their language, but can scarcely be said to have altered the racial characteristics of the inhabitants of these islands. The significance of the Anglo-Saxon and Scandinavian invasions was that they marked a new beginning in the human geography of the British Isles. The Norman invasion was not one of colonisation, but represented a replacement of the aristocratic government of the Anglo-Saxons by a feudal system.

Having learnt now something of the various strains of people that have gone to make up the British nation, we may turn to a consideration of the distribution of population in the islands.

An immense wealth of information concerning England in the latter part of the eleventh century is contained in the Domesday survey. For long, difficulties of interpretation resulted in this material being neglected in its geographical aspects until a team of workers under the general direction of Professor H. C. Darby undertook a systematic study county by county.[2] The study has virtually reached completion, and Professor Darby has kindly provided the distribution map of population density in Domesday England (Fig. 216). Certain problems present themselves in its analysis. The counties of Northumberland and Durham, and most of Cumberland and Westmorland, were not included in the survey, while Lancashire is treated in a far from thorough fashion. Thus in Fig. 216 there is no information of population density in the four northern counties, and Lancashire is estimated as having a density of under 2.5 per square mile. Domesday does not record total population but only heads of households, and to obtain total population a multiplier must be used, based on the believed size of the medieval family household unit. This has not been attempted on this map. A further problem is that serfs may not have been recorded as heads of households but as individuals: Fig. 216 has not been adjusted for this. What remains is the density per square mile of the *recorded* Domesday population. The resulting map has the advantage of revealing relative densities from area to area. A distinction may be made between the recorded counties of northern and west midland England, and the remainder of midland, southern and eastern England. The former was marked by a low density of population, with few areas above 12 per square kilometre (5 per square

1. On the importance of the Firth of Forth as a geographical barrier and the origin of the present Scottish counties, see W. C. Dickinson, 'The Sheriff Court Book of Fife', *Scottish History Society*, 1928.
2. The first of six volumes was published by the Cambridge University Press in 1952. The five regional volumes are now complete, and the sixth concluding volume is awaited (1969). Reference should also be made to Professor Darby's paper on 'The changing English landscape', *Geogrl J.*, **117**, 1951, 377–98.

mile). The latter was more densely populated, the greater part having a density of between 13 and 38 per square kilometre (5 and 15 per square mile), with Norfolk, Suffolk and parts of Lincolnshire and Sussex having even higher densities. The low density of population in the north may be related both to its poor development economically at this time and the devastation wrought by William I in his harrying of the north between

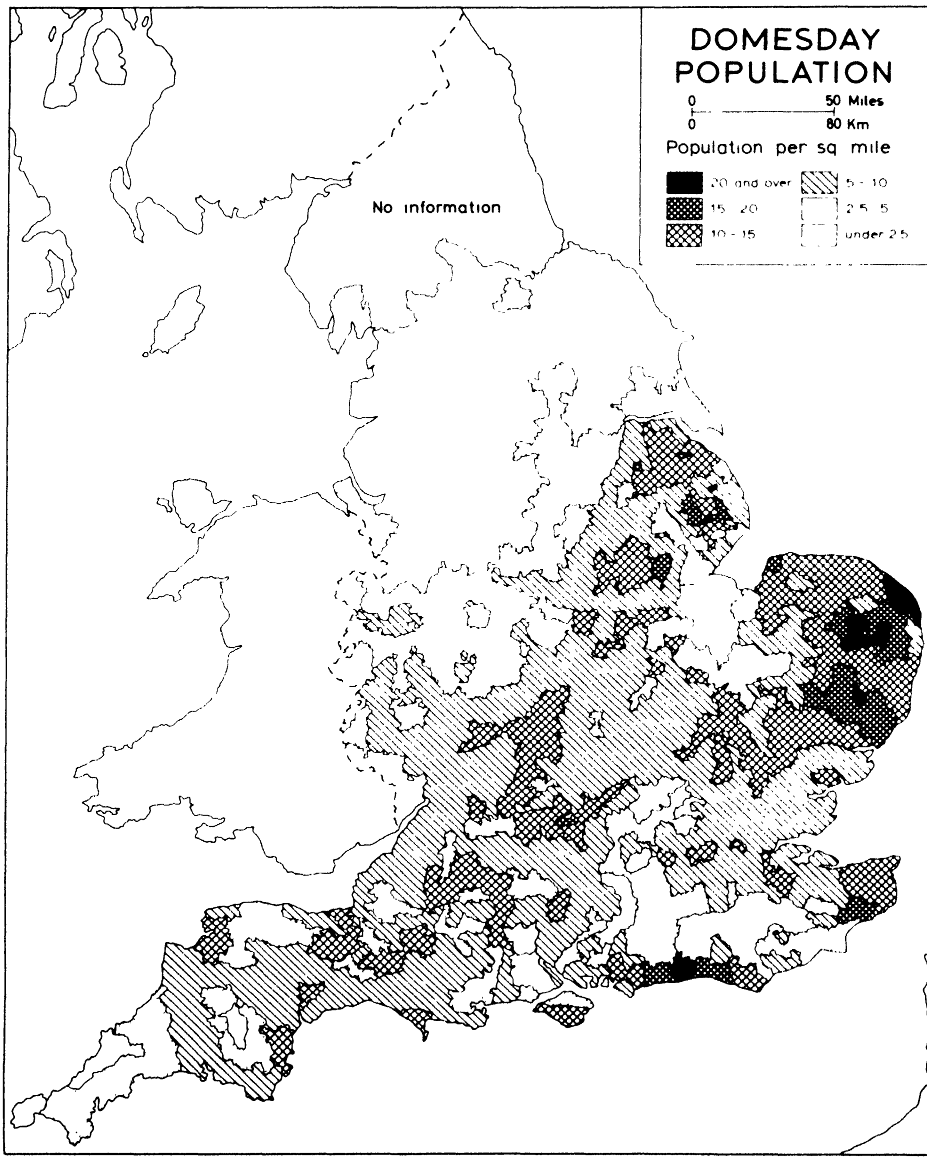



Fig. 216. Population of England at the time of the Domesday survey

1068 and 1070. Southern, eastern and midland England were areas of better agricultural land, which supported a higher density of population. This population contrast reflecting those areas with a better agricultural resource base was maintained until the eighteenth and nineteenth centuries and the revaluation of the north through industry. The influence of areas of difficulty on population density is also readily seen. The uplands of Cornwall, Dartmoor and the Pennines have low population densities, while the Fens and the woodlands of the Weald are marked by restricted settlement.

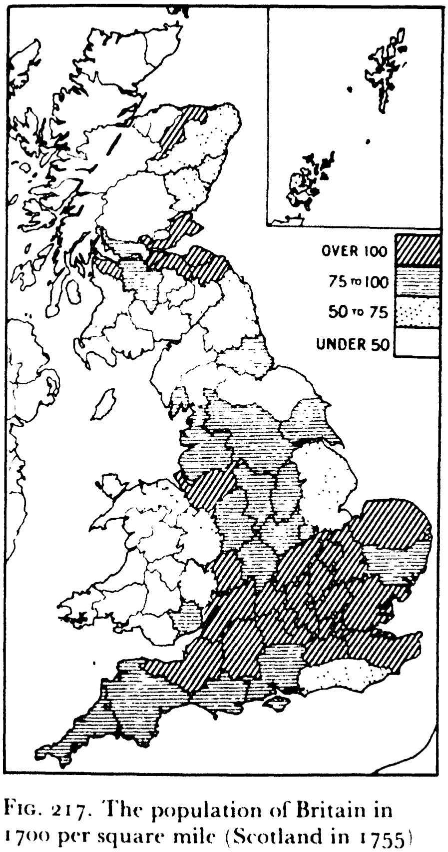



FIG. 217. The population of Britain in 1700 per square mile (Scotland in 1755)

The densest population was in the better agricultural areas, the coalfields had not yet exerted their influence

The emergence of the English people as a whole really dates from the days of Chaucer (*c.* 1340–1400) who was the first great writer to use the English language as opposed to Anglo-Saxon or Norman French. After the Norman conquest, there was no mass invasion of the country, but there were certain population movements. One of these was the influx of Flemings and Huguenot refugees, which had an important and lasting effect on

the development of economic life in this country.[1] Another was the intermittent incursions and peaceful settlement of western Scotland by migrants from Ireland, particularly early in the seventeenth century during the reign of James I of England.

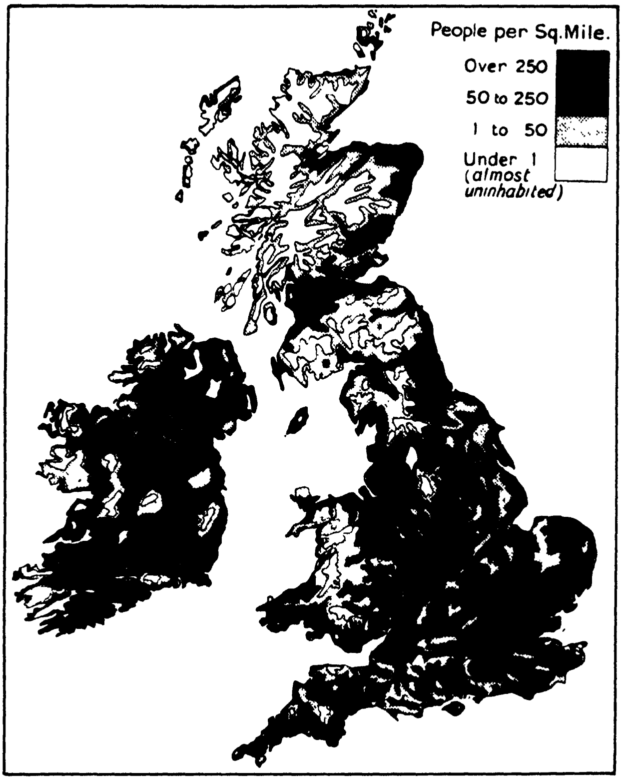



FIG. 218. The population of the British Isles in 1931
The divisions correspond roughly with industrial and intensive agricultural, good agricultural, poor agricultural and remote moorland tracts.
1 per square mile = 2.59 people per square kilometre.

To Scotland falls the honour of having taken the first census in Britain, compiled in 1755 by Dr Alexander Webster, minister of the Tolbooth Church in Edinburgh. Webster used his influential position as Moderator of the General Assembly in 1753 to secure from the parish ministers a return of the number of souls in their parishes, differentiating the two groups of Protestants and Papists. These early records of Scotland are particularly interesting since they show the distribution of population just prior to the period when Scotland changed from an agricultural and fishing country to one characterised by large-scale industrialisation in the Central Valley. Thus in 1755 the most densely populated counties in order were Banff, Berwick, Midlothian, Clackmannan, Fife and West Lothian, all, it will be

1. See pp. 493, 571.

noticed, on the drier eastern side of the country which has already been shown (see Chapter 11) to be the most suitable agriculturally to support a considerable population. It will be seen that the Midland Valley counties had not at this time succeeded in drawing to themselves the large populations which characterised them shortly after. It was largely owing to the influence of Malthus and the not inconsiderable stir that his predictions produced that the first official census of the British Isles was taken in 1801. From that time onwards the census was taken every ten years until 1931, and the table given on p. 640 shows the population of each of the constituent parts of the British Isles at each census and also the decennial rate of change. Throughout, the rapid increase at first and then the diminishing rate of increase is clearly indicated. An attempt has also been made to incorporate the effects of migration. Of course the key note of the last hundred years has been industrialisation—the increase of the industrial and urban population—accompanied by rural depopulation. An actual decrease in population did not set in as a rule until about the middle of last century or later. A study of the movement of population county by county, indicates at first a rise, practically speaking, in all counties, then a general decrease in the rural counties, but continued increase in all those counties which had industries. Quite frequently even the possession of a small industrial tract on the county margins was sufficient to turn the scale as, for example, in Denbighshire and Flintshire in Wales.

In general terms it may be said that there are in Britain two superimposed population patterns. One is the rural-agricultural with its isolated farms and farm-workers' cottages, villages and market towns, the whole strongly influenced by quality of land. The other is the urban-industrial, still expanding and spreading over the older pattern. At the present day rural depopulation is not an indication of decadence but of increasing agricultural efficiency—less labour needed to maintain production.[1]

Because the general movement of population has long been from the country to the towns it must not be presumed that all towns have increased in size. The rise and fall of settlements will be discussed in the next chapter. But whilst continued growth is the rule in the great urban agglomerations, which once they attain a certain size tend to increase of their own momentum, some of the smaller towns, especially those in Scotland, are losing their population at a greater rate than even the purely rural parishes. It is scarcely necessary to emphasise the way in which the coalfields have been the magnet for the attraction both of industries and the population which went with the development of industries. Exceptions were few. Naturally some of the

1. In some areas the 1951 Census revealed a rise in the population of rural districts and hence an apparent rise in the population officially classed as rural. Actually the increase represented an overspill from the towns into the surrounding rural districts. The same phenomenon is seen in Fig. 219 for the 1961 Census which also shows for London and other large cities a decreasing population in the centres where offices and shops are taking the place of homes.

larger ports continued to attract a population as their trade developed, but in reality they were serving for the most part as inlets or outlets for the industrial regions on the coalfields. The one main exception was London, in so far as its relationship to the coalfields is concerned, but after all London is really the port for the greater part of Britain. But post-1918 years brought about a distinctly new tendency. It may be described as the flight of industry *from* the coalfields, in large measure of course due to the more extensive use of electricity which could be generated on the coalfields or from waterborne coal and transmitted where required. To sum up, the tend-

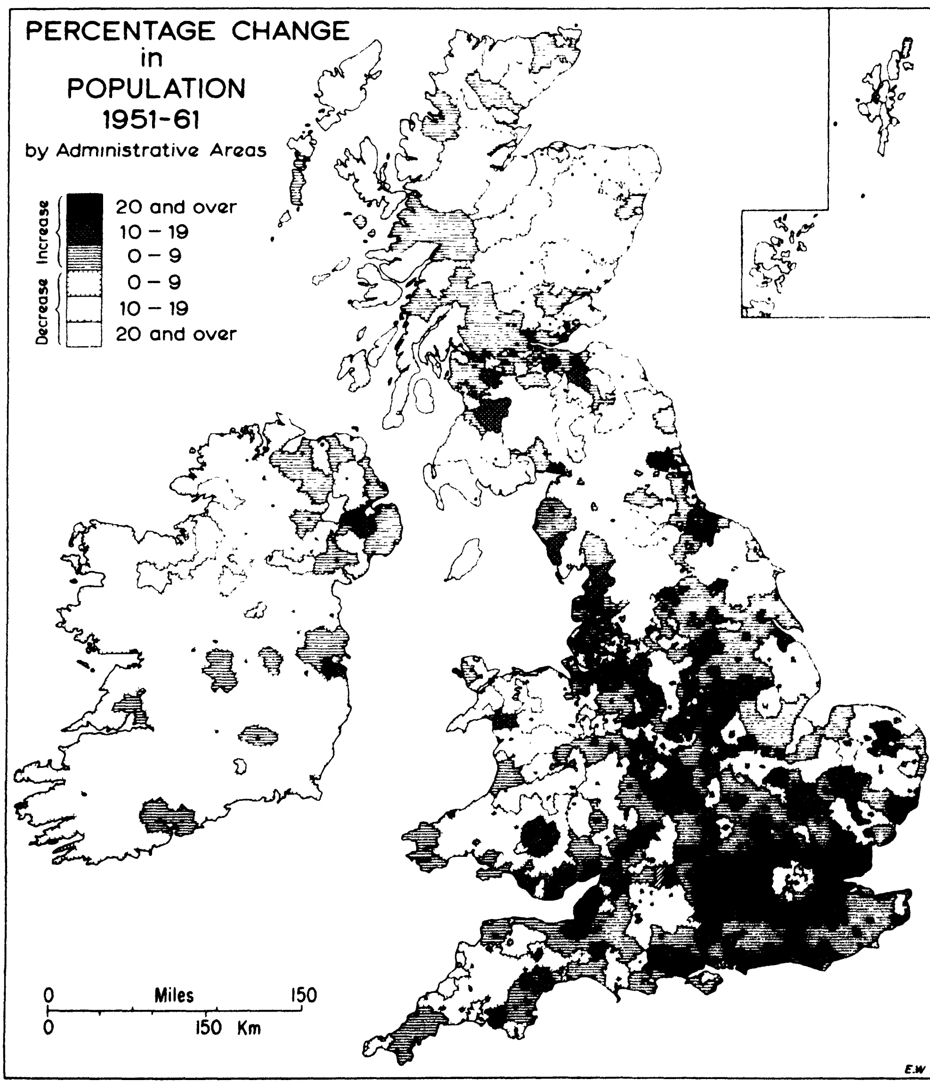



FIG. 219. Population changes in the British Isles 1951–61
Map specially prepared by the Geography Maps Office of the London School of Economics

encies in the intercensal period of 1921–31 may be described as showing continued rural depopulation, virtual or actual cessation of growth, and in cases even a decrease in the population of industrial regions and towns in the north compensated for by the continued phenomenal growth of London and of the development of the London region as a whole as a manufacturing area.

As a result of these interwar changes many of Britain's older industrial areas, associated notably with parts of the coalfields approaching exhaustion, suffered severely from unemployment. They became and for a time were known as Depressed Areas. When Government decided to take positive action to help them, they were designated and remain 'Development Areas' and are officially demarcated with additions made from time to time. Parts of central Scotland, the northwest and northeast coalfields, parts of Lancashire, North Wales coalfield and South Wales are the chief areas.

The main areas of really marked population increase were Greater London and Greater Birmingham. It was said that industry was moving south—actually what was happening was the establishment of new industries and new factories in the south and Midlands whereas in the older industrial areas obsolescent and abandoned factories were not being replaced. This meant that in the older peripheral areas there was much unemployment and taxes collected from the business of the prosperous centre were being used to relieve distress there. The Report of the Royal Commission on the Geographical Location of the Industrial Population (Barlow Report) recommended that there should be a national plan to secure a wider distribution of industry. This dispersal of industry was in fact secured by the wartime conditions of 1939–45 and is now part of national policy. It is made easy for manufacturers to establish new factories or industries in the 'Development Areas'. Despite official deterrents the results of both the Census of 1951 and that of 1961 showed a continued increase in the 'belt' stretching from Lancashire on the one hand to London on the other.[1]

The population of the Irish Republic decreased from 2 971 992 in 1926 to 2 965 854 in 1936 and to 2 960 593 in 1951, the period 1946–51 showing a slight increase. In the decade 1951–61 there was again a decrease—to 2 814 703 in 1961, rising slightly to 2 884 002 according to the Census of April 1966.

At first it might be thought that Ireland offers a different picture from Britain. But that is not the case. Ireland is essentially rural, and so has suffered depopulation in the same way as all rural parts of the British Isles. But as the diagram (Fig. 220) shows, depopulation was continuous from the decade 1841–51 to 1921 and was initiated by the great famines of the 1840s.

1. There has been much discussion on the reality or otherwise of this 'belt'. See *Geogrl J.* **103**, 1944, 49–72; also A. E. Smailes, in *Geography*, **29**, 1944, 41–51.

One of the remarkable features of recent years, especially from 1954, has been the influx into Britain of large numbers of British West Indians of Negro stock, especially Jamaicans. By 1963 Britain had a black population, many Negro, of some 300 000. As citizens of the British Commonwealth they were free to come and go. Large numbers of Pakistanis and Indians also came to Britain. They have been absorbed into the British economic system, especially as manual workers, in transport undertakings, and into the medical services. Numerous Hungarians fled to Britain in 1956 to escape the Russian military control, their numbers being added to the numerous Poles and other Europeans who had found refuge or political asylum in Britain during and after the Second World War.

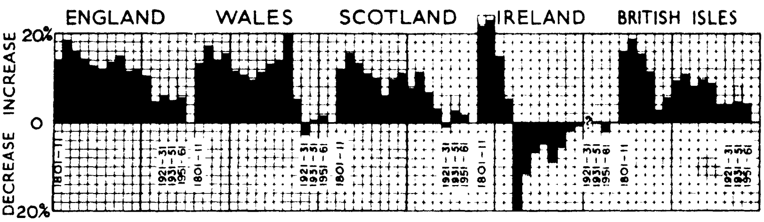



FIG. 220. Population changes in the British Isles, 1801–1961, showing decennial changes

*Population*

| YEAR | BRITISH ISLES | ENGLAND AND WALES | SCOTLAND | IRELAND |
|---|---|---|---|---|
| 1801 | — | 8 892 536 | 1 608 420 | |
| 1811 | — | 10 164 256 | 1 805 864 | |
| 1821 | 20 893 584 | 12 000 236 | 2 091 521 | 6 801 827 |
| 1831 | 24 028 584 | 13 896 797 | 2 364 386 | 7 767 401 |
| 1841 | 26 730 929 | 15 914 148 | 2 620 184 | 8 196 597 |
| 1851 | 27 390 629 | 17 927 609 | 2 888 742 | 6 574 278 |
| 1861 | 28 927 485 | 20 066 224 | 3 062 294 | 5 798 967 |
| 1871 | 31 484 661 | 22 712 266 | 3 360 018 | 5 412 377 |
| 1881 | 34 884 848 | 25 974 439 | 3 735 573 | 5 174 836 |
| 1891 | 37 732 922 | 29 002 525 | 4 025 647 | 4 704 750 |
| 1901 | 41 458 721 | 32 527 843 | 4 472 103 | 4 458 775 |
| 1911 | 45 213 347 | 36 070 492 | 4 760 904 | 4 381 951 |
| 1921 | — | 37 886 699 | 4 882 497 | 4 228 533[1] |
| 1931 | — | 39 952 377 | 4 842 554 | |
| 1951 | 53 327 333 | 43 744 924 | 5 095 969 | 4 329 587 |
| 1961 | 55 487 924 | 46 071 604 | 5 178 490 | 4 237 830 |
| 1968 (estimate) | — | 48 593 000 | 5 187 500 | — |

[1] Census year 1926 for Irish Free State and Northern Ireland.

*Decennial population changes* (percentages)

| YEAR | BRITISH ISLES | ENGLAND AND WALES | SCOTLAND | IRELAND |
|---|---|---|---|---|
| 1801–11 | — | 14.00 | 12.3 | — |
| 1811–21 | — | 18.06 | 15.8 | — |
| 1821–31 | 15.03 | 15.80 | 13.0 | 14.3 |
| 1831–41 | 11.24 | 14.27 | 10.8 | 5.5 |
| 1841–51 | 2.47 | 12.65 | 10.2 | −19.8 |
| 1851–61 | 5.62 | 11.90 | 6.0 | −11.8 |
| 1861–71 | 8.55 | 13.21 | 9.7 | −6.7 |
| 1871–81 | 10.80 | 14.36 | 11.2 | −4.4 |
| 1881–91 | 8.16 | 11.65 | 7.8 | −9.1 |
| 1891–1901 | 9.89 | 12.17 | 11.1 | −5.2 |
| 1901–11 | 9.04 | 10.89 | 6.5 | −1.7 |
| 1911–21 | | 4.93 | 2.6 | −3.4[1] |
| 1921–31 | | 5.16 | −0.8 | |
| 1931–51 | | 9.5 (4.75) | 5.2 (2.6) | 2.4[2] |
| 1951–61 | 4.1 | 5.3 | 1.6 | −2.1 |

[1] 1911–1926. [2] 1926–1951

Owing to the Second World War there was no Census in 1941. The figures in the penultimate row thus refer to twenty years (ten-year period in brackets).

*Number of passengers of British nationality leaving and entering the United Kingdom for and from countries outside Europe* (thousands)[1]

| | 1909–13 | 1926 | 1930 | 1933 | 1938 | 1946 | 1950 | 1960 | 1967 |
|---|---|---|---|---|---|---|---|---|---|
| Emigrants: | | | | | | | | | |
| To the Commonwealth | 276.3 | 132.3 | 59.2 | 20.8 | 29.0 | 110.2 | 112.9 | 79.4 | 203.1 |
| To foreign countries | | 166.6 | 32.9 | 5.5 | 5.1 | 56.6 | 17.3 | 9.2 | 59.8 |
| Immigrants: | | | | | | | | | |
| From the Commonwealth | 104.3 | 39.1 | 51.4 | 44.6 | 32.6 | 54.1 | 56.1 | 74.3 | 114.1 |
| From foreign countries | | 12.0 | 14.8 | 14.7 | 8.0 | 9.0 | 10.0 | 5.9 | 32.2 |

[1] From *Statistical Abstract of United Kingdom* and *Annual Abstract of Statistics*, 1926 was a peak year for emigration after the First World War, 1933 a low record.

# 25
# The evolution of the form and functions of British villages and towns

It seems clear that the settlements of Stone Age man were restricted to those areas where the natural vegetation cover was easily cleared (see p. 625). That such areas were available on the comparatively open belts, such as the chalk downlands of southeastern England, is reasonably certain (but see p. 119), though it has been argued also that there were other sites, notably gravel plains in the valleys, which were equally attractive.[1] As our knowledge of postglacial climatic fluctuations increases it becomes clear that in pre-Roman Britain when Neolithic man and his successors occupied the land the climate of these islands was more humid than at present, and that water supply in upland situations did not present the difficulty that it would do today. The Briton at the time of the first Roman raids relied upon the hoe for scratching the surface of the small square fields which he had cleared on the uplands or on the valley gravels, and this field system appears to have continued during the Roman occupation. The network of straight roads linking strategically sited towns developed by the Romans bore no relation to the agricultural land-use pattern of the earlier inhabitants. When the Romans withdrew, the earlier Anglo-Saxon invaders came as warring conquerors, who seem almost to have eliminated the Romano-British inhabitants, although this is debatable. But later they appear as land hungry settlers, penetrating by water routes to almost every part of Lowland Britain. By early Saxon times the normal human settlement had five primary requirements. (*a*) A supply of water; (*b*) an area of good lowland grazing, e.g. meadows on alluvium or by the side of streams; (*c*) Drier undulating land suitable for ploughing; (*d*) an area of common rough hill pasture for grazing. Such comprised a typical valley settlement; (*e*) a woodland area for fuel and building material. In the broader valleys the settlements would be on the banks of the stream, and the land proper to the village would extend from the damp pastures along the banks of the stream to the high ground on one side of the valley. The villages might be at intervals of a mile or more along the banks with a corresponding line along the other side of the stream. In the case of narrower valleys the village itself might

1. E. T. Leeds, *Geography*, **14**, 1928, 527–35. Probably, as suggested on p. 125, the alder woodland of these damp areas was more easily attacked by men armed only with stone tools than oakwood or other types of forest.

bridge the stream and its domain extend from the hills on one side to the hills on the other. In other cases a line of villages might be situated along a line of springs issuing from the hillside, the pasture land occupying the lower ground to the one side, the ploughed land the rough pasture the higher ground to the other, giving what are known today as spring line villages.[1] It is thus clear how the vill or smallest unit of administration came into existence. It was the land proper to a single village or settlement and its boundaries were naturally so arranged that it included areas of the three types of land mentioned.[2] With the reintroduction of Christianity into Britain at the end of the sixth century A.D., it was natural that a church should be added to the existing settlements, and the vill took on a new aspect; it became the parish, the smallest unit of our existing administrative system and originally a purely ecclesiastical area. It was the district served by the parish church and indeed the area from which tithe was payable to a given church, or in the first instance to the priest in charge. It should be noted that as the number of churches increased, so the size of parishes decreased. Examples are numerous in southeastern England of the apparently curious shape of parish boundaries which are due to the old-time necessity of including with the parish sufficient areas of the land of different types required by the rural economy of the period. Excellent examples are afforded in the south of Surrey in the parishes of Wootton, Abinger, etc. With the development of the manorial system sometimes the vill or township coincided not only with the parish but also with the manor. Sometimes, however, the vill had become divided into two or more manors, each of which had a parish church and so each became a distinct parish. Often the component parts in the original vill retained the old name, distinguished, however, by the addition of an adjective—such as the name of the lord of the manor or the saint to which the church was dedicated. Many of the picturesque names in the lowland counties of England are thus derived.[3]

It is clear that the typical arrangement just described would be characteristic of predominantly arable areas, but it must be remembered that large tracts of the wetter lowlands of England remained for long under damp oakwood. Probably the earliest settlements in these were mere clearings in the forest, that is, isolated homesteads. Later much of the damp oakwood became replaced by permanent pasture, and to this day in England the pastoral counties are characterised by disseminated settlements or iso-

1. Both types of village correspond to what some continental authors have called 'wet point villages'. It is only in the wet marshy district, e.g. plain of Somerset, that there is the necessity for the human settlement to occupy a drier point than the surrounding marshy lowlands, giving what may be termed a 'dry point' village. See B. M. Swainson, 'Rural settlement in Somerset', *Geography*, **20**, 1935, 112–24.

2. Vill seems a better term for these units than township, which tends to suggest an urban area.

3. For example, Compton Bassett, Berwick Bassett, Winterbourne Bassett (Wiltshire), Wiggenhall St Germans, Wiggenhall St Peter, Wiggenhall St Mary the Virgin, Wiggenhall St Mary Magdalene (Norfolk).

lated farms, whereas arable areas are characterised by the nucleated village.[1] Even when a number of the pioneer settlers were close together and formed a hamlet the population of the whole area would remain scanty and probably also poor. Not one of these hamlets or small vills would be sufficiently rich to support a church and a priest, and in such areas of Britain

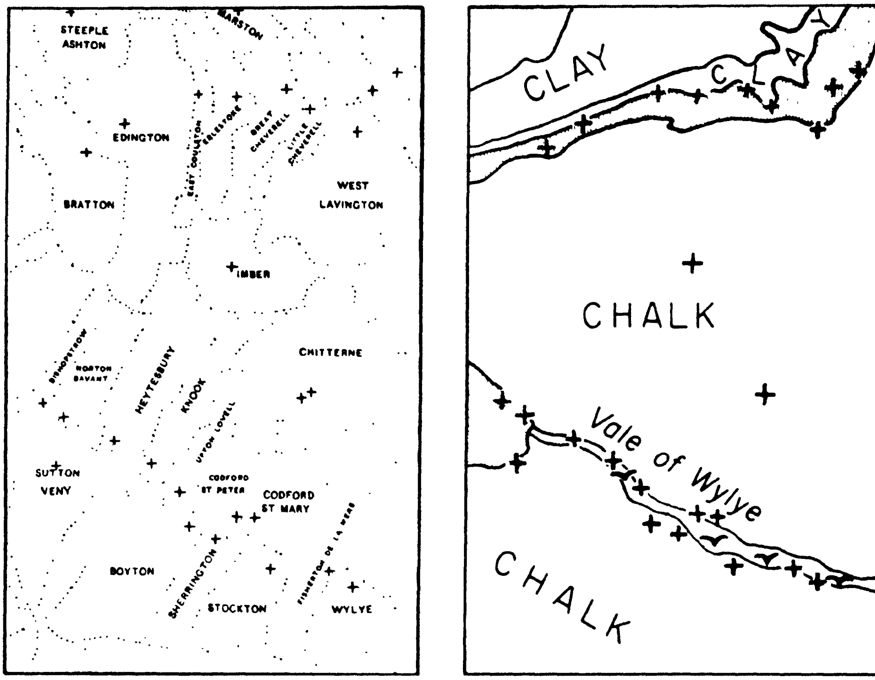



FIG. 221. Wiltshire parishes

Illustrating a line of valley settlements along the Vale of Wylye, with the village (the cross represents the parish church) near the stream in each case. In the north are 'spring line' villages along the outcrop of the water-bearing Upper Greensand on the southern side of the Vale of Pewsey. (Scale 4 miles = 1 inch)

as Cheshire and Shropshire, and the Marches of Wales, a church had to serve a large area of this sparsely peopled country, and a parish came to consist of as many as ten to twenty of the small vills or townships. Not infrequently these larger churches, collegiate churches as they were afterwards known, had two rectors; probably the duty of one being to tour the large parish.

1. See P. W. Bryan, *Man's Adaptation of Nature*, University of London Press, 1932. But in many cases when it was supposed that the isolated homestead was the original form of settlement, the supposition has been disproved. By way of contrast for different areas see E. G. Bowen, 'A study of rural settlements in south-west Wales', *Geog. Teacher*, **13**, 1926; H. King, 'The geography of settlements in south-west Lancashire', *Geography*, **14**, 1927, 193–200, and *J. Manchester Geog. Soc.*, **39–40**, 137–44; Dorothy Sylvester, 'The hill villages of England and Wales', *Geogrl J.*, **110**, 1948, 76–93. See also H. J. E. Peake, 'Geographical aspects of administrative areas', *Geography*, **15**, 1930, 531–46, and H. Thorpe, 'The green villages of County Durham, *Inst. Br. Geogr.*, **15**, 1949, 155–80.

Such large parishes of the west seem to have been designed to provide the maximum of convenience to their population. Although they are large they are usually roughly circular or oval without awkward prolongations, and the parish church is generally to be found near the centre. On the other hand, there are large, and often irregularly shaped, parishes in the arable eastern counties due to the action of lords of the manor. Where one man held a lordship over two or three adjoining manors he tended, for the sake of economy, to combine these and to be satisfied with one church and one priest for the whole of his estate. Some of the still more irregularly shaped

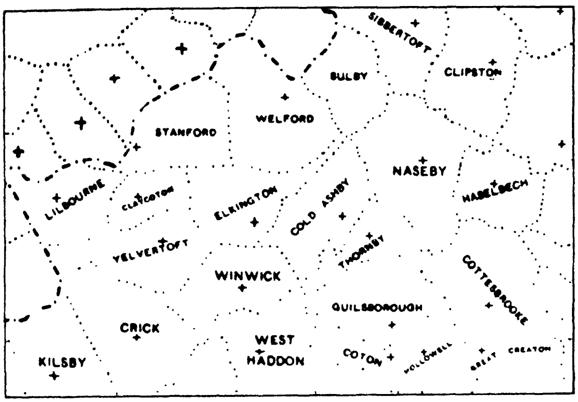



FIG. 222. Regular shaped parishes with the church and village centrally placed

Typical of the pasture lands of the Midlands and clay vales. Scale 4 miles = 1 inch.

For a classification of these villages by type of site see S. H. Beaver, *The Land of Britain, Part 58, Northamptonshire*, Land Utilisation Survey 1943, pp. 364–8

and unwieldy parishes owe their origin to the action of the monasteries, who endeavoured to augment their incomes from tithes by combining parishes irrespective of their boundaries, grouping them around the parish church which belonged to the monastery. This practice seems to have been prohibited in 1123, but already by that time a number of large and awkwardly shaped parishes that contradict all rational geographical principles had been formed. Each had, of course, one parish church, and the churches which had previously been parish churches, and which were still included within the boundaries, became chapels or chapels of ease. Other chapels of ease were often erected in large and populous parishes.

The majority of villages found today had been established by 1086 and were recorded in the Domesday survey. Additions to the village pattern have been relatively few. Of more importance is that since that time many villages have been lost to the landscape. It is estimated that there are more than 1300 deserted villages in England, with two main concentrations appearing—namely the Inner Midlands of Buckinghamshire, Leicester-

shire, Northamptonshire, Nottinghamshire, Oxfordshire and Warwickshire, and an Eastern Margin of Lincolnshire, Norfolk, Suffolk and Yorkshire. Thus in Northamptonshire and Oxfordshire respectively there are 80 and 100 recorded lost villages. Desertion has occurred at all times and for a variety of reasons. But in midland England the main period was between *c.* 1350 and *c.* 1450. In this area deserted villages were not the direct result of the Black Death, but were related to the economic depression that followed the plague. Cereal prices declined, and there was a movement from arable to sheep-grazing, the result of the high price of wool. Villages which had formerly been arable-orientated were depopulated to provide grassland for flocks.[1]

Most of the parishes of Britain are of very ancient origin, and retained their boundaries until a little over a century ago, when in the early part of the nineteenth century the growth of population, consequent upon the Industrial Revolution, necessitated the frequent carving up of very populous parishes into smaller units. Even this practice was not general until after the passing of an Act in 1856. It should be noticed that until Tudor times the parish had been a purely ecclesiastical unit, and it was not until the decay of the manor following the Black Death and the first agrarian revolution that the parish became a civil unit. When parish councils were created by the Local Government Act of 1894, the civil parishes almost invariably coincided with the ecclesiastical parishes. County councils were given power to subdivide large parishes, and although the power was not very widely exercised,[2] where it was, the new civil parishes were made to follow the ancient boundaries of the vills or townships. This was done, for example, in Cheshire.[3]

Returning now to the old vills or townships these were grouped into hundreds which normally consisted of ten or twelve townships, at least in southeastern England.[4] In the northeastern counties of England under Danish influence larger units were formed known as wapentakes. Many of the old hundreds are mentioned in the Domesday survey. Some of them are named after spots remote from villages lying in the middle of waste land; and one may look upon such a hundred as consisting of a ring of vills or parishes having a large area of common grazing land in the middle of which was a convenient meeting place. Others take their names from larger villages which had been growing into market towns. A meeting place in the midst of waste land proved to be less convenient than a meeting place in a large village, and undoubtedly many of the old market towns originated in this way. It has been suggested that when the hundreds take their names

1. See M. W. Beresford, *The Lost Villages of England*, 1954; also W. G. Hoskins, *The Making of the English Landscape*, 1955, pp. 93–5.

2. For although alterations were made to some 6000 parishes, the changes were in most cases very small.

3. See the *Historical Atlas of Cheshire*, ed. D. Sylvester, Chester, 1958.

4. Sometimes believed, at least in some cases, to have comprised roughly a hundred families.

from waste land it was a common practice for the men of the townships to meet there and sort out their cattle just as is done at the present day at the spring round-up in the great pastoral countries of the newer lands of the world. Disputes were settled by the hundred court, and hence the association of the hundred court later with market towns. The areas of the hundreds became irregular in just the same way as did the areas of the parishes, and gradually the hundred as a unit became less and less important, and local administration was based on the parish and on the county. After the Napoleonic Wars problems arose which were beyond the powers of parishes to solve, and a new unit came into existence which was the Poor Law Union created by the Act of 1834. The Unions were devised in a haphazard way regardless of geographical conditions, with the result that in less than a hundred years they have entirely disappeared. Their place has now been taken by Rural Districts.

The geographical counties of England are also of very early origin.[1] The majority go back to the time of the Saxons and a large number at any rate were in existence at the time of King Alfred. The counties south of the Thames, broadly speaking, correspond to old kingdoms. Thus in the south-east of England the Anglo-Saxon Kingdom of Kent (Cantii) occupied an area roughly conterminous with Kent. It is to be observed that the areas of these old counties are natural geographical units, and their boundaries are natural geographical features. The frontiers particularly used were the sea, a river, a line of hills such as the chalk scarp—a tract of dense almost impenetrable woodland or marshland, or an area of barren heath. Thus Kent stretched to the sea and the river on the north, to the sea on the east and to the south as far as the great impenetrable mass of woodland which then occupied the Weald. It must be remembered of these natural barriers that the woodlands have disappeared, even the areas of barren heathland have been largely utilised. Another example is afforded by Sussex, which represents the territory of downland held by the South Saxons (Regni) and which was cut off by the woodland of the Weald from the rest of England. As the woods of the Weald were gradually cleared and settled so that territory was divided between Kent and Sussex. Norfolk and Suffolk form an interesting example of a natural region, occupied in pre-Roman days by the Iceni. It was bounded by the sea on the north and on the east; by the marshland of the Fens on the west; by the thick forests, which must have covered the London Clay lowlands of Essex, on the south. The only landward entry into this region was the narrow belt of chalk downland stretching away to the southwest.[2] When the territory of the Iceni was invaded and settled

1. The fifty-two ancient or geographical counties of England and Wales should not be confused with the sixty-two administrative counties which themselves exclude the eighty-three county boroughs or towns with the status of a county.

2. Along which was the Icknield Way (cf. Ic(k)eni Way, a possible, but unproved derivation) crossed by a succession of dykes or protective earthworks.

by the East Anglians they divided it into the North Folk and the South Folk —hence the modern counties of Norfolk and Suffolk.

Turning to the midland counties of England, dense, damp oak woodland covered their lowlands to a much later date. As we have just seen, this woodland was only gradually cleared and occupied by settlers. It would seem that the Midlands of England were arbitrarily divided into shires or counties in the tenth century in the course of the wars between Wessex and the Danes. The method followed seems to have been that certain leading

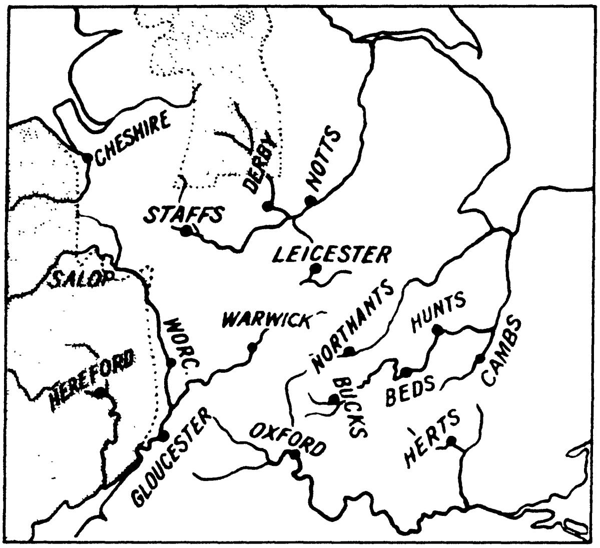



FIG. 223. Map showing the Midland 'shires' or counties of England grouped about the county town, in each case on a navigable river (after C. B. Fawcett)

settlements or military strongholds, such as a Danish borough,[1] were chosen as capitals of the shires, and around these were grouped such areas as at that time could conveniently be administered. Thus the midland shires of England are not the natural geographical units that the southern and eastern counties are. One notices how many of these midland shires are still named after the principal town. The very names of the old southern and eastern county kingdoms do not need the addition of the word shire, and the name of the county town often bears little or no connection with that of the name of the county, whereas in the Midlands of England we have Bedford, Bedfordshire; Northampton, Northamptonshire; Oxford, Oxfordshire, Warwick, Warwickshire; and so on. It is very interesting to notice how many of these artificially arranged midland shires are still awkward

1. The majority on navigable rivers, emphasising the importance of river transport in low land, still largely forested.

administrative units, and present difficulties in administration even to the present day which are not found in those counties based on the natural geographical units of the old kingdoms.[1]

Returning now to the development of settlements, we may take first of all purely rural areas: that is areas which have remained rural to the present day. If one looks upon a village as a convenient point of settlement from

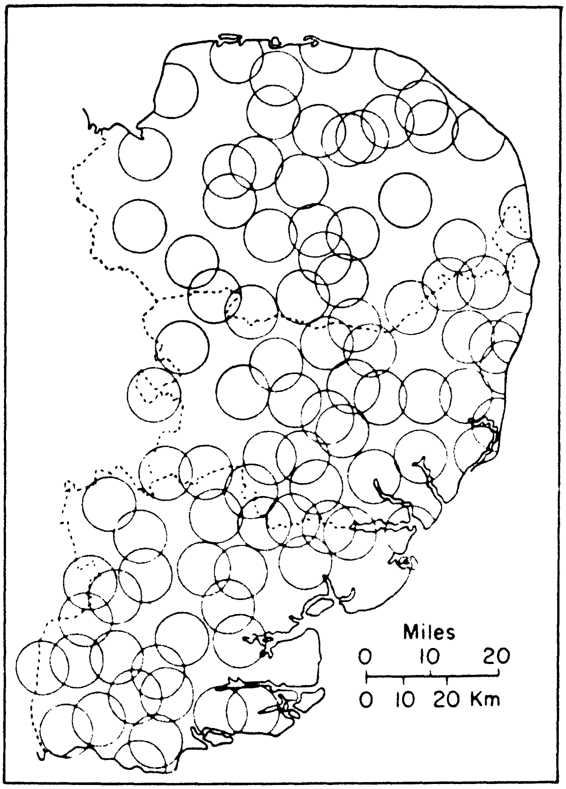



FIG. 224. The medieval market towns of East Anglia

Showing each with an arbitrary limit of 6.4 kilometres (4 miles) radius (after R. E. Dickinson)

which the land of the surrounding vill was cultivated then one gets the idea of the primitive village as an essentially agricultural settlement. The first requirement of the people would obviously be a market centre to serve a small collection of vills, where they could exchange their commodities with one another, could sell the surplus that they had, and buy such of the simple

1. An immense amount of information is to be gained by a study of place names. Many county volumes have been published by the Place Name Society, and a convenient general guide is *The Oxford Dictionary of English Place-Names*, by E. Ekwall, Oxford University Press, 2nd edn, 1940.

necessities from the outside world as the requirements of early days demanded. But there was already an organisation which required the federation of eight or a dozen vills and this was the hundred. So it is often the case that one of the larger villages became the market town or centre of the commercial life of a hundred. It is an obvious step from this to the same town becoming the administrative centre of the hundred, e.g. for purposes of the

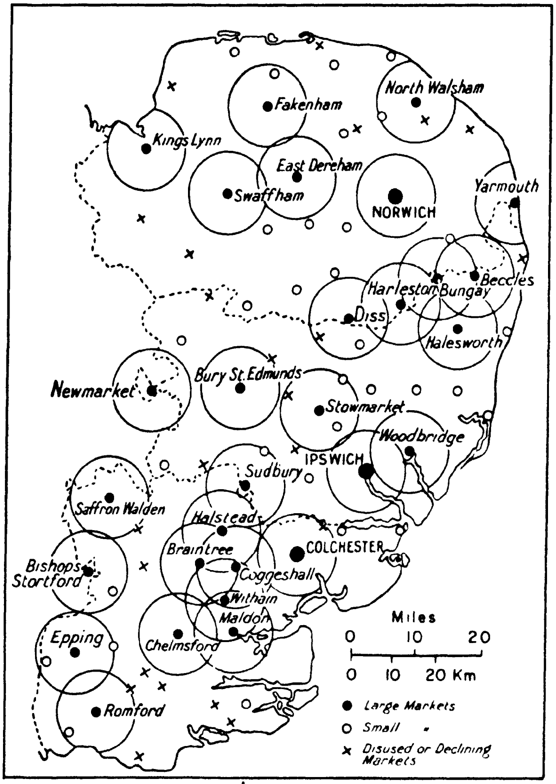



FIG. 225. The market towns of East Anglia, about 1834

Showing each with a limit of 10 kilometres (6 miles) radius (after R. E. Dickinson)

administration of the law. In other cases the administrative function may have preceded the development of a town as a market or commercial centre.

The market towns of medieval England were closely spaced. The visit to the market town had to be made on foot, or if a carriage or other conveyance were available the condition of the tracks or roads of the countryside was so execrable that the radius served by a market town was not very appreciably increased. Although the use of rivers may have been important in appropriate cases it is clear that in the more settled rural parts of England between 11 and 16 kilometres (seven to ten miles) was regarded as the proper

distance between marketing centres. Indeed, there is an old law still in existence which makes it illegal to establish a market within 10.7 kilometres ($6\frac{2}{3}$ miles) of an existing legal market. In an interesting study of the distribution and functions of the urban settlements of East Anglia, R. E. Dickinson[1] suggested that the maximum range of influence of the medieval market was about 6.4 kilometres (four miles), and he drew a map to show an arbitrary market area of 6.4 kilometres (four miles) radius to each medieval town in East Anglia (Fig. 224).

Not all towns grew naturally. In the Middle Ages, many 'new towns' were established where previously there had been no settlement.[2] In England and Wales there are 256 recorded 'new towns'. Over 90 per cent of these came into existence between 1066 and 1350, a period of economic growth and colonisation. During these three centuries trade, industry and population were growing sufficiently to permit the siting of 'new towns' between the established market centres. Landlords were aware of the value in terms of increased rent-roll of having merchants and traders centred at one place on their land. In Wales the majority of plantations were fortified, being associated with Edward I's Welsh campaigns, but they developed market functions simultaneously. Many of the 'new towns' prospered, and for example Caernarvon and Newcastle-under-Lyme, founded in 1283 and between 1154 and 1162 respectively, are today thriving centres. But not all 'new towns' were successful: of the 256 recorded plantations, 16 per cent were failures. Thus New Radnor in Radnorshire founded in 1257 is but a village today.

It is remarkable how long this primitive arrangement of marketing and administrative centres remained; and it was not until about the middle of the eighteenth century that changes occurred. The gradual development of road transport after about 1780 in particular resulted in the concentration of marketing in fewer towns due to the increased marketing radius which was possible. In the main, nodality, with ease of communications in different directions, was the factor which determined the survival of the fittest. In the early part of the nineteenth century it was possible to classify the market towns of the rural countryside into three groups, large, small and disused or rapidly declining (Fig. 225). This was the state of affairs in 1834 when the Poor Law Unions were brought into existence, and the market towns were constituted headquarters of the Poor Law Union districts and the seat of the Board of Guardians. But the bad designing of the unions soon became apparent; for there followed the great development of railways and the macadamisation of roads. People could easily go 12 or 15 kilometres (eight or ten miles) to or from their market town far more easily than their forefathers two or three generations ago could travel half that distance.

1. *Geography*, **17**, March 1932, 19 31; see also 'The town plans of East Anglia', *Geography*, **9**, 1934, 37 50.
2. M. W. Beresford, *New Towns of the Middle Ages*, 1967.

Roughly speaking, every alternate market town decayed, and the prosperity of the intervening ones increased. The remaining market towns were given what may be described as a new lease of life when they became the centres of the new rural districts. In the separate county parts of *The Land of Britain*, the Final Report of the Land Utilisation Survey, the distribution and functions of the agricultural markets are considered as they were in the 1930s. Broadly speaking, livestock markets, for example in the southwest, are closely spaced whereas grain and produce markets, as in East Anglia, draw from a much wider area. The reasons are obvious.

The early progress of towns in what are now industrial areas was, of course, similar. Early industrialisation seems to have been fostered by one or two main causes: (*a*) the inhabitants of the town tried to utilise for manufacture raw materials supplied to them by the visitors to the market; the rise of the woollen industry using the wool sold by local farmers is thus characteristic of Norwich and certain towns of East Anglia; (*b*) the inhabitants found that they could supply the needs of some of their neighbouring agriculturalists by goods made in their own centre. It would seem that the early trade in horseshoes and other small iron objects in Birmingham started in this way—with a supply to farmers in the local districts; the iron ore being available near at hand and charcoal for smelting it from the neighbouring forests. The cutlery industry of Sheffield may be cited as a similar instance. Natural advantages and a near-at-hand market for the produce were responsible for the inception of the industry. Thus, leaving on one side altogether the ports, a number of small manufacturing centres sprang up all over England. The Industrial Revolution and the flight of the industries to the coalfields resulted in the disappearance of many of these small industrial centres and in the immense development of others.

## Functions of urban settlements

Here we may break off for a moment and consider what are the essential functions of a town or an urban settlement. Grouped into broad categories the functions may be described as follows:

(*a*) Commercial.
(*b*) Administrative.
(*c*) Industrial.
(*d*) Social.
(*e*) Residential.

A study of the urban settlements of the British Isles shows that the relative importance of these functions varies from town to town. Sometimes the one may be so important as to overshadow all the others. There are reasons why the study of the functions of a town are of the utmost importance, particularly at the present day. One of these reasons is that it is perfectly clear that town planning must be varied not only according to the site which is avail-

able, but according to the functions of the town concerned. Let us attempt, therefore, to analyse in slightly more detail each function.

(*a*) *Commercial.* The function is concerned primarily with the buying and selling of goods. The larger the town the greater the cleavage or difference between wholesale and retail. In all the larger towns there is usually a definite commercial centre. It may be represented in the large market town of a rural county by the cattle market and its surrounds—the storehouses of the corn chandlers and of the vendors of agricultural implements. In a town of a different type it is represented by the closely spaced streets of large warehouses. But in either case the wholesale commercial centre is divorced from the retail shopping area. The growth of a town as a wholesale commercial centre depends above everything else on its nodality and its transport facilities. Under this heading comes naturally the relationship between the commercial centres of the larger towns and the railway and road systems on the one hand, and the facilities for the import of goods on the other. Thus in the larger ports we find the warehouses, representing the commercial centre, grouped near or around the docks.

(*b*) *Administrative.* For purposes of administration, particularly for administration applying to the whole county, undoubtedly one of the factors of greatest importance is ease of accessibility to all parts of the area concerned from the centre chosen. Quite frequently the county town has ceased to be ideal from this point of view—especially when it is essential to retain vital and immediate contact with some large centre on the borders of the county. Thus the county offices of both Lanarkshire and Dunbartonshire are in Glasgow. For many purposes Kingston-on-Thames and not Guildford is the county town of Surrey. Much of the business of the county of Essex is conducted from its London office.

(*c*) *Industrial.* It is important to realise how many of our larger towns are essentially industrial, whilst they are neither commercial nor administrative in an important sense. The reverse is also true. Manchester and Leeds are primarily the commercial and to some extent administrative centres, as well as in some degree social centres, of a manufacturing area in each case, rather than being primarily industrial. We have considered elsewhere in this book the requirements of industrial centres, and these points need not be reiterated: but just as the commercial and the administrative offices of a large town are frequently collected together in definite areas, so also—even more markedly—are the industrial works. Provided the essential requirements of easy receipt of raw material and easy despatch of finished articles are satisfied then the town planner can do much to direct industrial development round an existing town in those ways which will best serve the whole community.

(*d*) *Social.* The social functions of an urban settlement are not always fully realised or given their proper importance. Women form more than half the population of the British Isles, and it is calculated that over three-quarters of the money passed over counters in retail stores is passed over by women. In other words, women do the shopping. Yet how many women pay a visit to a town with the purely utilitarian motive of shopping and nothing else? This question might have a double question mark after it. For is it not true to say that the choice of the town and the choice of the route are not infrequently determined by the attractive nature of the displays in the shop windows; the possibility of a lunch in a pleasant restaurant with music, and a visit to a cinema where light and life—real and unreal—afford a relaxation from the daily round and common task? In the larger towns or for longer journeys, such as a trip to London, there may be the added attraction of the theatre. The hotel and the club must be near at hand. It is particularly in the evening that the town exercises its social influence over men and women together. This conjunction of the social services is of the utmost importance, because in town planning one cannot divorce the shopping centre from the centres of amusement such as we have described. What is the quintessence of the importance of the West End of London and of other cities which boast a West End? Or of Broadway and Fifth Avenue in New York? In certain towns another factor of importance comes in and that is the influence of the church. No one who has lived in a smaller cathedral city can fail to appreciate the importance of this factor and its influence. In some areas schools and colleges exert a somewhat comparable influence.

It is often forgotten that there are large numbers of towns in the British Isles where the social influence is paramount, and where the fostering of the social influences becomes the main industry of the town. This is, of course, the case with seaside resorts and with inland spas. With all her richness in scenic beauty and historic remains Britain has not realised the full possibilities of what has now come to be called the tourist traffic or 'tourism' (see above, p. 618). For example, how many British seaside resorts have so far developed their attractions in the winter months that one may unhesitatingly go for a weekend being assured of a lively and sustained period of relaxation from daily business? Here the modern generation, not unreasonably, demands things on a large and lavish scale. Nothing could be more miserable than the seaside resort with three-quarters, perhaps all, of its places of amusement closed for the winter; and nothing could be more attractive than a fine pavilion—well lit, with music, food, and a view of the sea—in the winter months. In the preceding chapters of this book, it will be found that a number of quite large towns have scarcely been mentioned. They have little or no concern with industry, they are not ports nor commercial nor administrative centres. They are in fact essentially social-residential cities and towns. A leading member is Bournemouth—the youngest large town in Britain; others include Harrogate, Bath, Buxton (spas); Scarborough, Cromer, Margate, Eastbourne, Torquay, Newquay,

Llandudno, Blackpool and Douglas (I. of Man) (seaside resorts). A pioneer study of their evolution was made by E. W. Gilbert (*Scott. Geogr. Mag.*, **55**, 1939, 16–35), and he has since analysed the development of Brighton in detail (*Geogrl J.*, **114**, 1949, 30–53).

(*e*) *Residential.* There are some towns which are mainly residential. They are either dormitories for the large cities such, for example, as many of the smaller towns in a ring round London, or they may be the residential town for an industrial area, as Newcastle-under-Lyme is for the once smoky Potteries towns of the North Staffordshire coalfield. But a fact, again too often forgotten at the present day, is that there are very few areas which can be purely residential in this sense. They must either have absolutely first-class facilities for communication with the larger centres, or they must develop their own social life. Expensive housing estate schemes and garden city suburb schemes have proved failures for this very reason; and here arises a big question which the Britisher has not yet decided. His choice at present is between the semidetached villa with the little strip of garden where he may amuse himself in the evenings, but from which he has to face daily his half-hour's or his hour's journey to and from his business, and the flat in a large block where he has at hand the social attractions of the city, including the public parks with their beds of flowers, probably so superior to anything that he could have produced in his own little garden had he been a dweller in the suburbs.

This disquisition on the functions of urban settlements has been rather a lengthy one; but it is a subject to which more and more thought is being given in England. For a true interpretation of trends is a necessary prelude to a successful planning for the future.

## Town and country planning

It is true that a town or city in the fullest sense of the term has all its functions fully developed. Fifty years ago the late Professor C. B. Fawcett, in a stimulating little book,[1] outlined a scheme for the division of England and Wales into provinces, each province, of course, with a provincial capital. It is clear that he had in mind the necessity of a provincial capital having fully developed all the functions above outlined for towns.

When Fawcett wrote, it seemed unlikely that Britain would ever be divided into provinces and such was the comment made by us in the first

1. *The Provinces of England*, recently edited by W. G. East and reissued, 1960.

edition of this book. The outbreak of the Second World War and the imminent danger of invasion led to the division of the country into Civil Defence Regions each with a Commissioner representing the Central Government and with headquarters in a centrally placed city or regional capital. The regions were quickly adopted by many government departments for their own purposes, with this remarkable difference—that each department, and frequently individual divisions within a department, decided for itself the number, boundaries, and capitals of its regions. When the war came to an end the regions or provinces were firmly established and civil servants allotted by their departments to the regions carried in many cases the title 'provincial'—for example the Provinicial Land Commissioner of the Ministry of Agriculture—or in other cases 'regional' such as the Regional Planning Officer. Most departments recognise about nine or ten provinces for England; Wales forms at least one other, whilst Scotland for many purposes is divided into four. A comparative view of the many different regional divisions adopted up to the time he wrote has been given by E. W. Gilbert (*Geogrl J.*, **94**, 1939, 29–44).

Some of the provinces suggest themselves with their provincial capitals, others are far from satisfactory. For example some parts of the Southwestern Province are more difficult to reach from Bristol, the provincial capital, than from London. Similarly although East Anglia is a natural province, its obvious capital Norwich is less conveniently situated in many respects than Cambridge, which several ministries use for the purpose. Cambridge has the advantage of easier and quicker access from London, yet Norwich has the natural attributes of a provincial capital. Centrally situated on the East Anglian plateau, it is even so a port. Its large cattle, sheep, and pig markets point it out as the natural capital of a predominantly agricultural area; and it is, of course, the administrative centre of the large county of Norfolk. It has developed manufactures of two main types: the food industries utilising the produce of the farmers of the region; and side by side with them the manufacture of agricultural implements and such things as wire netting which are required in quantity by a farming community. In other cases its industries have undergone an interesting process of evolution. When the woollen and worsted industries departed to the coalfields, manufacture of boots and shoes—of recent years fancy shoes for women—was deliberately introduced. The totality of its civic and religious life, the intense local patriotism, the extent and variety of its shopping centres, and its amusement facilities leave no doubt as to the importance of the city as a social centre.

The study of towns and their zones of influence or 'urban hinterlands' has become of great practical importance in connection with physical planning and reconstruction following the Second World War. In a pioneer study of Leeds and Bradford some years ago, Professor R. E. Dickinson showed the complexity of the problem—that there might be tracts of country relying on one centre for certain purposes, on another for other

purposes.[1] In the Land Utilisation Survey's Report on Hampshire, F. H. W. Green paid special attention to public road services in determining urban hinterlands or 'umlands', and he developed this idea when he became Maps Officer to the Ministry of Town and Country Planning (a Ministry created in 1943, but merged into Housing and Local Government in 1951). On the basis of bus services, he demarcated the whole of England and Wales into 'urban hinterlands'. The main criticism of the method is that the picture can be quickly and radically changed by simple alteration of the bus services provided.[2]

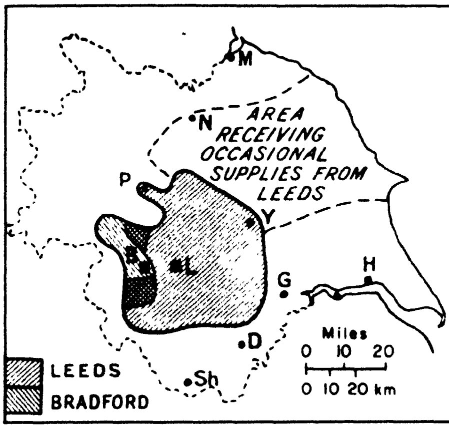



FIG. 226. The zones of influence of Leeds and Bradford as distributing centres

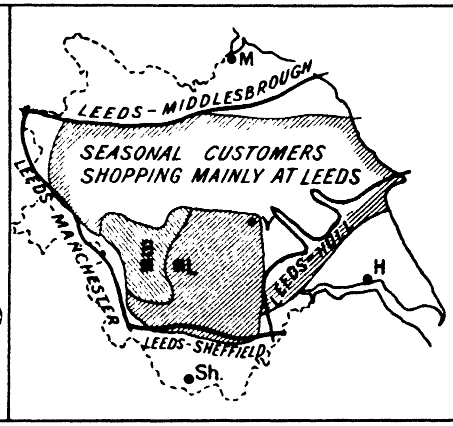



FIG. 227. The zones of influence of Leeds and Bradford as market or shopping centres
The heavy lines mark lines of equal accessibility or time by train of the two towns mentioned in each case.

A practical attempt to overcome the disadvantages of a long journey to work was initiated by the Government after the Second World War in two ways. One was by encouraging industry and consequent development in some of the smaller towns, the other was by the deliberate creation of a dozen New Towns – a ring around London in Crawley, Bracknell, Stevenage, Hemel Hempstead, Welwyn, Hatfield, Harlow and Basildon; at Corby; Aycliffe and Peterlee in Durham, Cwmbran in South Wales, East Kilbride and

1. "The regional functions and zones of influence of Leeds and Bradford', *Geography*, **15**, 1930, 548–57. Here Leeds is the regional capital, Bradford the great manufacturing city. For a modern treatment of this theme see A. J. Brown, 'What is the Leeds Region?', in *Leeds and its Region*. British Association for the Advancement of Science, 1967, pp. 200–14.
2. F. H. W. Green, 'Urban hinterlands in England and Wales', *Geogrl J.*, **114**, 1950, 64–88. See also Ordnance Survey 1/625,000 map of 'Local Accessibility', 1955. A more general treatment is that given by A. E. Smailes, 'The urban mesh of England and Wales', *Trans. Inst. Br. Geogr.*, **11**, 1946, 87–101.

Cumbernauld near Glasgow, and Glenrothes in Fifeshire.[1] These were planned *ab initio* on what are usually called garden city lines with a spacious layout and a low density both of houses and people per square mile. The New Towns thus take part at least of their inspiration from the pioneer garden cities of Letchworth and Welwyn. They differ from garden suburbs (such as Hampstead Garden Suburb and Wythenshawe, Manchester)

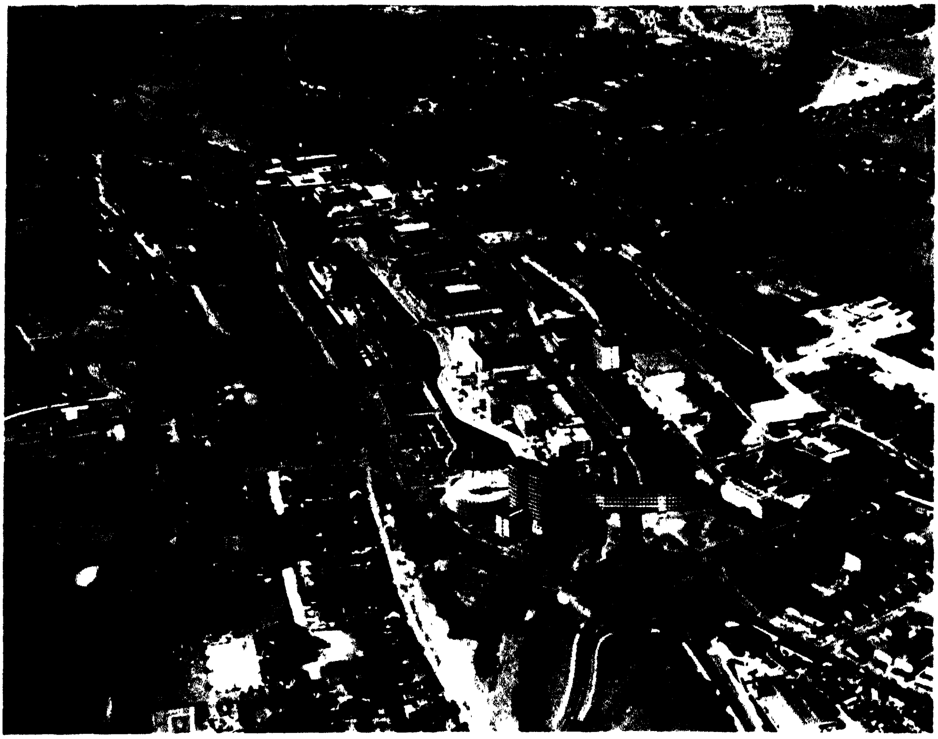


PLATE 25. A 'New Town' – Hemel Hempstead, Hertfordshire

This illustrates the grafting of a New Town on to an older settlement. The New Town centre, with its blocks of buildings and its water garden, lies in the Gade valley. In 1969 the total population was 66 000, some 40 000 of whom were in the New Town section

which are mainly residential. Elsewhere trading estates (i.e. estates where factory buildings are constructed for letting) have been used as nuclei of new or extended urban developments—as at Trafford Park (Manchester), which dates from 1902, Team Valley (Tyneside), and Slough (Greater London), which were developments mainly of the interwar years.

Side by side with such planned urban development has grown the national desire to preserve the best of the past, whether historic buildings

1. Others have since been added, notably Skelmersdale in Lancashire and Dawley, Shropshire (now called Telford). See Fig. 77.

(many now owned by the independent National Trust, or 'scheduled' as such by the Government) or the countryside—hence the activities of such bodies as the Council for the Protection of Rural England (CPRE) and the creation of National Parks under the official National Parks Commission.

Modern developments in town and country planning have also rendered it imperative to study more precisely the problems of rural population—including rural depopulation. Official figures show rather more than 80 per cent of the British population as 'urban', rather less than 20 per cent 'rural'. The rural population as officially defined is that living in Rural Districts which may include quite large towns (e.g. Didcot, the railway town in Berkshire). The truly rural population living in isolated farms or cottages, hamlets, and villages does not exceed about 10 per cent of the total. Here agricultural mechanisation may well lead to a further decrease in the labour force required, increased mobility by bicycle, motor-bicycle and car as well as by buses leads to a concentration of retail supply sources in the towns, the smaller families now usual may result in such small numbers of children in the villages that schools can no longer be kept open. Indeed the whole social structure of country life is threatened. The suggestion made by Stamp some years ago to distinguish in the rural populations three groups is now commonly used.[1] These groups are:

(*a*) The primary rural population of farmers, farm workers, and their families,
(*b*) The secondary rural population of those who exist to provide essential services to the first group,
(*c*) The adventitious rural population living in the country by choice.

It has been found that group (*c*) may be entirely absent in country valuable agriculturally, but less attractive residentially (such as large parts of the Fens), and that in such cases (*a*) and (*b*) are in the proportion of 2:1. In most cases it is found that a vigorous rural life—an active parish council, live social, religious, and educational institutions—often depends largely on the adventitious population, including retired people, hence its importance.

## Conurbations

It has long been recognised that the British census figures gave a quite inadequate measure of the relative size and importance of the larger centres of population because the figures refer to the areas defined by local government boundaries. Actually the densely populated areas are contiguous and form continuous urban areas. One of the best known examples of this, of course, is that of Manchester and Salford. Thus the term conurbation—suggested by the late Sir Patrick Geddes—has come to be widely adopted.

1. *The Land of Britain, Its Use and Misuse*, first edition, p. 448.

Professor Fawcett defined a 'conurbation' as 'an area occupied by a continuous series of dwellings, factories, and other buildings, harbours, and docks, urban parks and playing fields, etc., which are not separated from

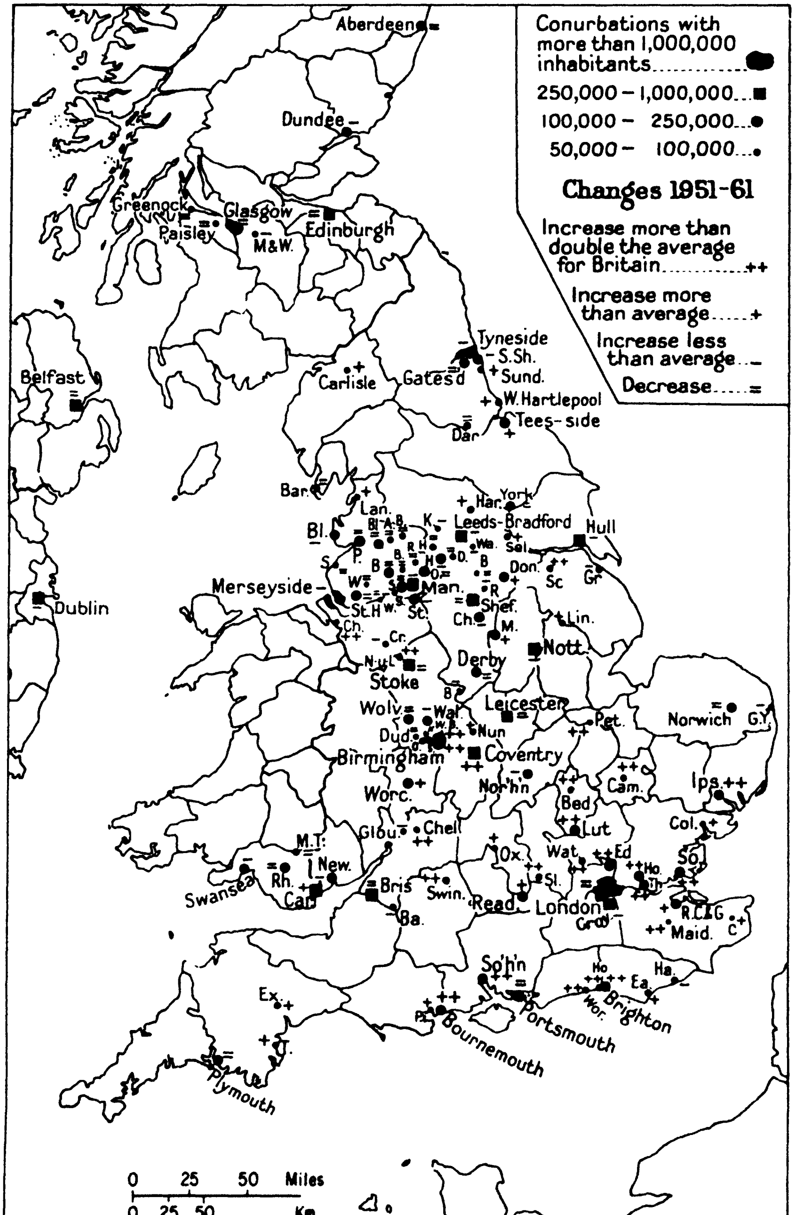



FIG. 228. The larger towns of Britain (all with more than 1 000 000 inhabitants are marked and County Boroughs over 50 000), and their population changes, 1951–61

each other by rural land; though in many cases in this country such an urban area includes enclaves of rural land which is still in agricultural occupation'. On this basis there were at the time of the 1931 Census no less than seven large conurbations in Great Britain, six of which had more than a million people; and there were also thirty other towns with more than 100 000 people.[1] It was found that 40 per cent of the total population of Britain was living in the seven 'million cities' or conurbations—half the total urban population. The Census of 1951 gave official recognition to each of these conurbations which were defined in terms of complete local government areas. The seven conurbations thus officially recognised are as follows:

1. Greater London, with an aggregate population of 8 346 137 in 1951, and covering some 1865 square kilometres (720 square miles). Separate consideration is given below to London (Chapter 26). The same area had 8 171 902 in 1961, and 7 764 000 in 1968.
2. Southeast Lancashire or Greater Manchester—with the continuous urban area of Manchester and Salford in the centre, and a number of smaller urban districts closely joined therewith, thus giving an inner ring with more than 1 million inhabitants. Round this, at a distance of from twelve to eighteen miles from the central point, is what may be called the Manchester ring: the towns of Bolton, Bury, Rochdale, Oldham, Stockport, etc., all being linked to the central core by regular bands of urban character. The total population in 1951 was 2 421 011 over an area of 982 square kilometres (379 square miles). It had increased to 2 427 000 in 1961, and 2 441 000 in 1968.
3. The West Midlands or Greater Birmingham and the Black Country. The city of Birmingham contains about half the total urban population in this total area of 694 square kilometres (268 square miles) and 2 236 723 people in 1951, increased to 2 344 000 in 1961, and to 2 425 000 in 1968.
4. The West Yorkshire conurbation, of which Leeds and Bradford are the two largest members, and which includes most of the woollen towns of the West Yorkshire coalfield, has a total area of 1243 square kilometres (480 square miles); its population of 1 692 190 rose to 1 703 000 in 1961 and to 1 730 000 in 1968.
5. Merseyside—including Liverpool, with two-thirds of the total population, and Birkenhead and Wallasey on the opposite side of the Mersey—covers 383 square kilometres (148 square miles) and had 1 382 244 people in 1951 but only 1 386 000 in 1961, with a further decline to 1 351 000 in 1968.
6. Tyneside, of which the natural centre—Newcastle—contains about a quarter of the total population, covers 233 square kilometres (90 square

1. Where the urban areas are not continuous the term 'town cluster' may be used and is appropriate for the Black Country, or the ring of towns around Manchester mentioned above, or the West Riding woollen towns outside Leeds and Bradford.

miles), and had 835 332 people in 1951, 852 000 in 1961, and 843 000 in 1968.

7. Glasgow. The Central Clydeside conurbation, focusing upon Glasgow, covers 834 square kilometres (326 square miles) and contains just over one-third of the population of Scotland. In 1951 it had 1 758 000 people, in 1961 1 766 000, and in 1968, 1 755 000 (of whom 945 000 were in Glasgow itself).

A comprehensive study of these and other smaller conurbations is contained in T. W. Freeman, *The Conurbations of Great Britain*, Manchester University Press, 1959. From a different point of view C. A. Moser and W. Scott, in *British Towns*, Oliver & Boyd, 1960, have developed a 'typology' of towns.

# 26
# London

What is London? Before attempting any description of London and its activities, it is necessary to attempt to define what the name 'London' connotes. For at least half a dozen different boundaries are in common use, each enclosing a tract which, for specific purposes, is considered as 'London'.[1] Two of these are precisely defined administrative units—the City of London which is the original heart of the whole, 2.6 square kilometres (one square mile) in extent, and the Greater London Council area, created in 1963, covering 1606 square kilometres (620 square miles). The former County of London had been created by the Local Government Act of 1888; it was carved out by taking parts of the counties of Kent, Surrey, Middlesex and Essex, and was divided into forty-one districts, which were re-grouped in 1899 into twenty-eight metropolitan boroughs. Despite its area of 303 square kilometres (117 square miles) the County proved inadequate before many years had passed to contain the population whose life and work were centred in London. The loose designation 'Greater London' came to include the City, the County, and a variable outer ring. Specific definitions of Greater London have been used for different purposes: the London Transport Board area covers about 5180 square kilometres (2000 square miles), the Metropolitan Police area 2020 square kilometres (780 square miles), the Metropolitan Water Board area 1475 square kilometres (570 square miles), and the London postal area 608 square kilometres (235 square miles). The population of 'Greater London' given by the Census figures for 1921 and 1931 refers to the Metropolitan Police area. For the purpose of the 1951 Census Greater London or the London conurbation was precisely defined in terms of administrative units, and this Registrar General's area is more or less the same as the Police area, with minor modifications that reduce its extent to 1865 square kilometres (720 square miles). It should be noted that when Sir Patrick Abercrombie prepared the Greater London Plan, 1944, to cover postwar redevelopment and expansion, a much wider area was taken into consideration.

A Royal Commission on Local Government in Greater London was appointed in 1957 and produced its report in 1960; its recommendations

1. For a map showing all the various boundaries see Jones and Sinclair's *Atlas of London*, 1968, Plate 8.

were radical—a drastic reduction in the number of local authorities and the abolition of the Counties of London and Middlesex, and the creation of an overall planning and traffic authority, the Greater London Council. The result was the London Government Act of 1963, which established the GLC, the Inner London Education Authority (whose area covers the old County) and thirty-two London Boroughs. The population of the area was about 8 million, incorporating 3.25 million from the former County, 2.25 million from Middlesex, about one million from each of Surrey and Essex, half a million from Kent and about 60,000 from Hertfordshire.

## The City

The smallest unit which may be designated 'London' is the City of London, commonly called the City, coinciding roughly with Roman London and with medieval walled London, though overlapping both to some extent. The City is only a little over 2.6 square kilometres (678 acres) and, lying wholly to the north of the river, includes the two hills separated by the long since obscured Walbrook. To the west the City extends beyond the medieval Lud Gate and the valley, where once the Hol-bourne flowed into its estuary the 'Fleet', as far as Temple Bar. Here, until 1878, a bar in the form of an archway across Fleet Street actually existed to mark the limit of the City of London, and at this point it is still the custom of the Lord Mayor to present the sword of the City to the ruling sovereign on his entry. The City is still the hub about which the great wheel revolves. London became a world exchange for almost every commodity as well as the greatest centre of banking and insurance, and as such earned the proud title of the commercial capital of the world. The City is still the heart of this commercial London, but it no longer has the monopoly that it had until the First World War. Every important business house in the world has offices or representatives in London. Before the war a deliberate policy of limitation of height of buildings prevented the building of skyscrapers, and commercial London had to expand laterally and so invaded the formerly residential or 'social' areas of Westminster and the West End. Great office buildings of the interwar period, such as Bush House, are outside the City, whilst other office buildings of the same period such as Thames House and Imperial Chemical Building are even farther west than the Houses of Parliament. But the City still has within its bounds the Bank of England (The Old Lady of Threadneedle Street—rebuilt in the interwar years, from within, with the exterior unaltered), the Stock Exchange, and the great commodity exchanges as well as the world-famous insurance corporation of Lloyd's, the ancient Guildhall, and the official residence of the Lord Mayor (the Mansion House). The City suffered severely by bombing during the Second World War, especially the section between St Paul's Cathedral and the Bank and rebuilding in large tall blocks has altered its character. The preservation of St Paul's itself, almost unscathed, was virtually a miracle.

The ever increasing pressure on space required for office accommodation —half a million office workers are employed in the City and a further 600 000 in the West End—has naturally resulted in a steadily decreasing residential population. Compared with 128 129 in 1801, by 1931 only 10 996 persons, largely resident caretakers, were recorded as actually living in the City, but nearly half a million came in daily to work in its offices. By 1961, the total had fallen to 4771. The deserted City on a Sunday morning is a sight not to be forgotten.

## Inner London

'Inner London' comprises the City of London and the area formerly known as the County of London. The latter includes twelve of the new London Boroughs (see Fig. 230) which have replaced the City of Westminster and twenty-seven former metropolitan boroughs. The new borough of Tower Hamlets (formerly Bethnal Green, Stepney and Poplar) lying to the east of the City coincides roughly with what is popularly designated the 'East End'. The East End is still essentially industrial, and some of the leading industries will be noted later, whilst the southern parts, Stepney and Poplar, include some of the docks of the Port of London. Several of its outstanding features—its rows of small, too frequently squalid, houses, its innumerable little shops—the East End shares with the majority of industrial towns, but the large alien population is a distinctive feature. Whitechapel, lying within this area, is popularly, and largely correctly, associated with a major part of London's Jewish population; Limehouse with London's 'China Town'. The East End suffered severely from wartime bombing which destroyed or seriously damaged approximately 20 per cent of all houses in Britain, thus creating a very serious housing shortage. This led, in London as elsewhere, to a conflict of policies. Any house which could be rendered habitable was patched up; any vacant space might be used for temporary prefabricated homes erected from sections ('prefabs') leaving but limited space for imaginative rebuilding on modern lines. One of the best examples of the latter is the Lansbury Estate of Poplar. Elsewhere sheer necessity has led to the building of blocks of flats, despite the strongly held belief among many that the Englishman will always prefer an individual home.

To the immediate west of the City of London is the City of Westminster. Less than 200 years ago it was still a pleasant walk through the fields from London to Westminster, but it has long since been impossible to the ordinary Londoner to distinguish where one begins and the other ends. In Westminster are the Houses of Parliament and that street of Government buildings, Whitehall, with its famous, if insignificant, offshoot Downing Street. Westminster merges into and in many respects is part of the 'West End'. Here the fashionable residential area still clings round the parks and squares, whilst London's great shopping centres lie along the main thoroughfares.

But blocks of flats have largely replaced ducal mansions, offices and shops are invading the quiet residential squares, office buildings are replacing hotels. The West End includes also that curious enclave of somewhat squalid streets, famous for its varied foreign population and its restaurants, known as Soho—a local industrial area largely dependent on the main shopping centres near by. The West End is ill-defined and merges outwards on the west and north into the upper-class residential areas. The East End, the City, the southern parts of the new boroughs of Camden and Islington (formerly Holborn and Finsbury), and the West End may be regarded as

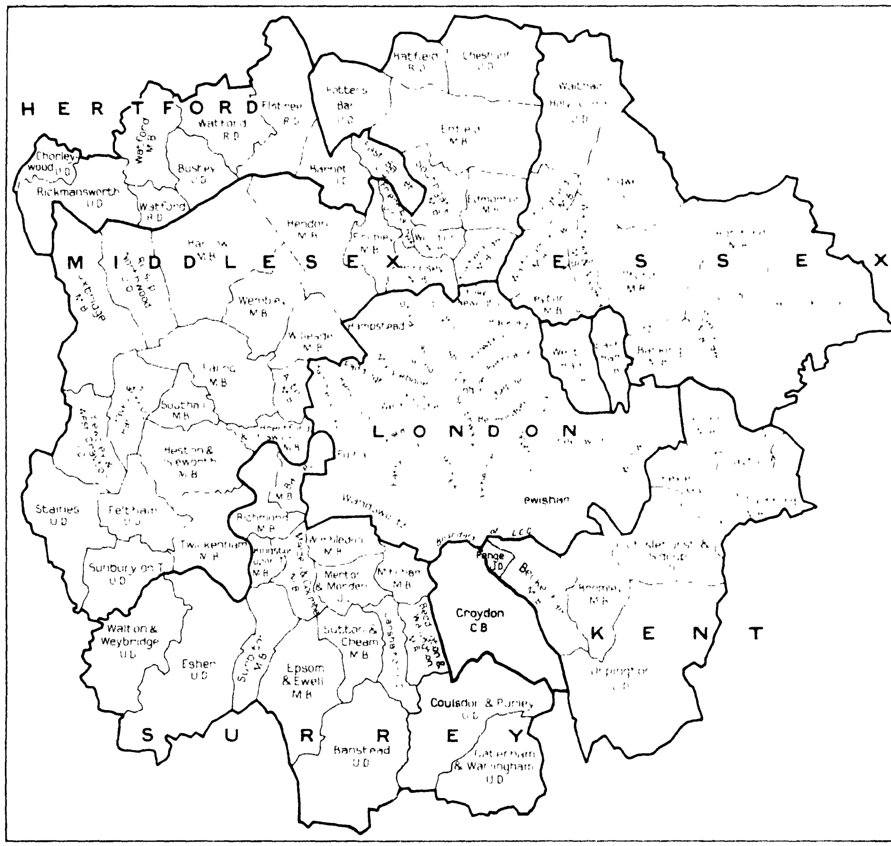



FIG. 229. The administrative divisions of Greater London, 1961
Compare with Fig. 230 which shows the post-1963 position.

constituting central London, but to the north and west, within the county, there lies a large area, partly residential, partly industrial (the former Metropolitan Boroughs of Paddington, Marylebone, Hampstead, St Pancras, Islington, Stoke Newington, Hackney, Chelsea, Fulham, and Hammersmith). That part of London lying south of the Thames is largely

industrial and commercial in its inner ring, and residential towards its outer margins. Much of the housing—as well as other building—is obsolete or obsolescent and awaits reconstruction.

## Greater London

The area administered by the Greater London Council comprises Inner London, as defined above, plus twenty London boroughs. It is a slightly smaller area than the Greater London of the 1961 Census (compare Figs. 229 and 230). This outer ring of boroughs, largely suburban in character though with numerous local centres and industrial zones, may be described as London's dormitory, for a fair proportion of those who live therein journey daily to some point in Inner London to earn their daily bread. But the ring includes areas of very different character:

(*a*) Some of the boroughs nearest to Inner London are really an integral part of London proper. Thus the largest of London's docks lie in the borough of Newham (formerly East Ham and West Ham), and the industrial district of the East End merges insensibly into Newham and Barking (including the former borough of Dagenham). Similarly on the south side the Woolwich industrial area is continued into Erith (now part of the London Borough of Bexley); and on the northwest Willesden (now part of the borough of Brent), Acton (now part of Ealing) and Brentford (now part of Hounslow) continue the industrial and nineteenth-century residential areas of Paddington and Hammersmith.
(*b*) On the other hand, some boroughs in the outer ring retain an entity of their own as local centres—for example, Croydon, Kingston-upon-Thames and Barnet.
(*c*) In other tracts, notably in the northwest sector and especially along the main lines of the former Great Western and LNW railways, new industrial centres have developed in the heart of the outer ring (see below, p. 681).

Greater London in another sense (as used, for example, by Abercrombie in the Greater London Plan) embraces an even larger area stretching to the crest of the chalk hills on the north and even beyond them on the south, and is thus equivalent to rather more than the central part of the London Basin. An increasingly large number of those whose business takes them daily to London take a pride in living 'outside the suburbs' and this they are enabled to do by the increased transport facilities. By the 1930s the ever-extending electrified services of the Southern Railway ran out as far as the coast at Hastings and Brighton: on the north the Metropolitan Railway extended beyond Aylesbury, whilst to the east the number of season ticket holders to Southend was very large. Since the war, the Liverpool Street suburban lines have been electrified, and the main-line electrification from Euston has brought places like Northampton and Rugby within commuting range of London. The ever-extending sprawl of London has led not only

to an apparently insoluble traffic problem of rush-hour traffic, to a journey to work absorbing two or even three hours of each day, but also to a virtual extinction of any rural country within 30 or 40 kilometres (twenty or twenty-five miles) of the centre. This has resulted in conscious planning to limit the growth of London by imposing a green belt, wherein building is prohibited or severely limited, by offering inducements to manufacturers to


FIG. 230. Administrative areas of Greater London, as reorganised in 1963.

expand elsewhere, and by building New Towns to serve as self-contained 'overspills' for London. Most of the towns on this periphery of the London area have their local functions as market towns serving (with the help of local bus services) the immediate countryside, as well as their functions as dormitory towns for Londoners. One solution to part of the London problem is to develop them as self-contained units, rather than as dependants upon London itself.

The influence of the metropolis extends, of course, much farther. A very large part, if not the whole, of the four Home Counties (Hertfordshire, Essex, Kent, and Surrey) as well as Sussex, southern Buckinghamshire, etc., is engaged in supplying dairy produce and vegetables to the London

markets. The 'economic tentacles' of the metropolis thus extend out in all these directions. The motor-car has brought the whole of the southeast coast from Bournemouth to Yarmouth within the normal limits of the car-owning Londoner's Saturday or Sunday trip—with a corresponding congestion on most of the direct roads.

## Physical factors influencing the growth of London

The site of early London was determined in the main by the presence, near the navigable river, of the hills, safe above flood level, now crowned by St Paul's Cathedral and the Royal Exchange or Cornhill. From the early

FIG. 231. London in 1820

The solid black shows the built-up area at that date. White on black: The City; dotted: built up 1666 (from Mayne's *The Growth of London*, by permission of Messrs George Harrap & Co. Ltd.).

days the physical features of the whole of the London Basin have not failed to exert their influence on the growing city. Residences spread outwards along the gravel terraces and ridges where a water supply was available, but where drainage prevented a waterlogging of the soil. The lower valleys of some of the streams draining to the Thames and many tracts of clay

remain to us to this day as the open spaces of Hyde Park, St James's Park, and others; the Lea Marshes still remain open land. For long the flood plain of the Thames itself must have presented a picture of a waste of marshland, flooded at high tide, but gradually embankment along the southern shore (opposite the City) permitted the formation of 'polders' occupied by cattle pastures. Below London, the great areas of marshland, such as the Isle of Dogs, remained until the great dock building companies began to utilise them in the nineteenth century. With the embanking of the river on both sides the water channel was restricted within narrow limits and little now remains to remind us of the extent of the old flood plain. But as London grew, the better residences sought the well-drained heights capped by gravel and the low-lying London Clay tracts remained undeveloped—occupied by pastureland. The gravel terraces west of London furnished

FIG. 232. London in 1945

The solid black shows the built-up area at that date. Figs 231 and 232 are on the same scale (from Mayne's *The Growth of London*, by permission of Messrs George Harrap & Co. Ltd.).

arable land, and the area that was formerly southwest Middlesex still sends much market-garden produce to London, though London's great airport at Heathrow has taken up much of the open land which remained. The roads out of London of necessity made for the gaps through the chalk ring; settlement followed along these roads and give an early example of what

has later been called 'ribbon development' (Fig. 232). At a much later stage the railways had to seek the chalk gaps and triangular tracts of farmland were left between them. A few tracts still remain: others were built over in the interwar years. It is found that most which remain are low-lying London Clay tracts. Modern drainage, water supply and improved foundations have played their part in making these clay lands usable, but the better residences sought the chalk slopes or the gravel-capped heights of the Surrey Hills or the Northern Heights.

## The population of London

The following table serves to illustrate the changing nature of population distribution in London:

| | CITY | REMAINDER OF COUNTY | OUTER RING | TOTAL GREATER LONDON |
|---|---|---|---|---|
| 1801 | 128 129 | 831 181 | 155 334 | 1 114 644 |
| 1841 | 123 563 | 1 825 714 | 286 067 | 2 235 344 |
| 1881 | 50 569 | 3 779 728 | 936 364 | 4 766 661 |
| 1921 | 13 709 | 4 484 523 | 2 995 678 | 7 480 201 |
| 1931 | 10 996 | 4 385 825 | 3 805 997 | 8 202 818 |
| 1951 | 5 268 | 3 343 068 | 4 997 801 | 8 346 137 |
| 1961 | 4 771 | 3 190 343 | 4 976 788 | 8 171 902 |

*Note* All figures before 1961 are adjusted to the pre-1963 administrative areas. In 1968 Registrar General's estimate the population of Greater London had fallen to 7 764 000.

These figures are sufficient to indicate the general trend: the decreasing population of the City and adjoining 'business' divisions of London. Indeed, Inner London as a whole has shown a declining population since 1901. The enormous increase is in the outer ring, whilst if one takes the area *outside* the 'Greater London' of official reports (i.e. the Metropolitan Police area) the percentage increase in the new outermost ring is even greater. This is likely to become even more marked when the ring of new towns (see p. 657) is complete. In the area outside the county considered in the Abercrombie plan the population rose from 4 084 900 in 1919 to 6 117 300 in 1939. Greater London of the Plan had thus over 10 million people, or a quarter of the total for Britain.

There is thus an ever-increasing outward movement of the population, but it must not be forgotten that this is accompanied by an ever-increasing *daily* movement of the people from their homes in the suburbs to their offices, shops, and factories in central London. Thus the resident population of Central London was, according to 1957 estimates, 226 000, whilst the employed day population was 1 352 000. In most London boroughs there is

a daily movement outwards of workers going to their occupations elsewhere, and also a daily movement inwards of workers resident elsewhere. For the County of London alone the number of persons so moving daily was over 2.5 million, a stupendous figure representing 11 per cent of the total occupied population of the whole of England and Wales at that time.

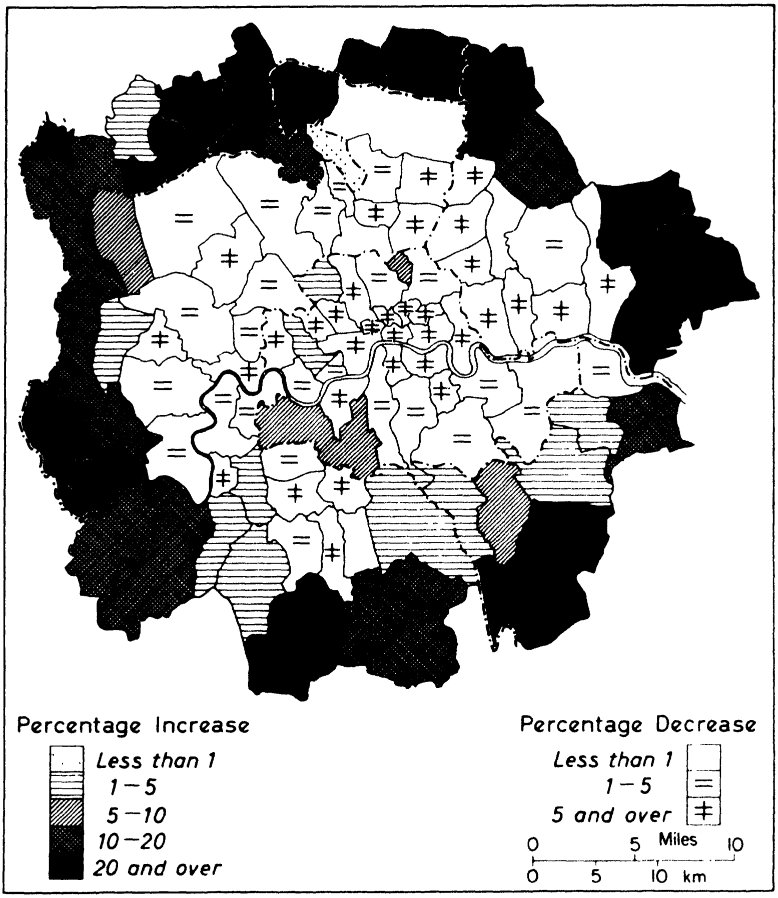



FIG. 233. Population changes in Greater London, 1951–1961

Even as long ago as 1921, the resident population of the City, Westminster, Finsbury, and Holborn was far smaller in each case than the transient population of workers who moved in and out daily. As the resident population of the central boroughs has decreased, so the daily movement has increased. Broadly speaking, it is the shop and office workers who come in from the suburbs to the City and the central boroughs: the industrial workers live near or at least nearer their work though they often move outwards from the very areas which receive a daily influx of black-coated workers.

# Employment in Greater London

The tables that follow give figures for the main groups of employment in Greater London in 1921, 1951, 1961 and 1966. This period was one of great increase in employment in the London conurbation which is the largest single employment region in the British Isles.

*Employment in Greater London, 1921 and 1951*
(arranged in Standard Industrial Classification Groups)

| | CLASSIFICATION | THOUSANDS 1921 | 1951 |
|---|---|---|---|
| I. | Agriculture, forestry, fishing | 27.7 | 17.1 |
| II. | Mining and quarrying | 1.3 | 2.7 |
| III. | Treatment of non-metalliferous mining products | 17.6 | 33.1 |
| IV. | Chemicals | 56.2 | 95.7 |
| V. | Metal manufacture | 12.2 | 24.7 |
| VI. | Engineering | 160.1 | 357.5 |
| VII. | Vehicles | 59.3 | 143.8 |
| VIII. | Other metal goods | 38.8 | 73.8 |
| IX. | Precision instruments, jewellery, etc. | 45.4 | 70.0 |
| X. | Textiles | 23.3 | 26.8 |
| XI. | Leather, leather goods, etc. | 27.4 | 21.3 |
| XII. | Clothing | 218.1 | 185.0 |
| XIII. | Food, drink and tobacco | 136.0 | 146.3 |
| XIV. | Wood and cork manufactures | 68.2 | 89.9 |
| XV. | Paper and printing | 139.6 | 173.3 |
| XVI. | Other manufacturing | 50.4 | 81.4 |
| XVII. | Building | 146.9 | 283.1 |
| XVIII. | Gas, electricity and water | 50.4 | 85.2 |
| XIX. | Transport and communication | 346.6 | 420.3 |
| XX. | Distributive trades | 534.9 | 599.3 |
| XXI. | Insurance, banking and finance | 109.9 | 186.9 |
| XXII. | Public administration and defence | 210.3 | 317.0 |
| XXIII. | Professional services | 207.1 | 365.0 |
| XXIV. | Miscellaneous services | 483.4 | 484.7 |
| | Other occupations | 45.0 | 4.5 |
| | Total | 3216.1 | 4288.3 |

Source: P. G. Hall, *The Industries of London since 1861*, Hutchinson, 1962.

*Employment in Greater London, 1961 and 1966*
(arranged in Standard Industrial Classification Groups)

| CLASSIFICATION | | THOUSANDS 1961 | 1966 |
|---|---|---|---|
| I. | Agriculture, forestry, fishing | 11.6 | 7.3 |
| II. | Mining and quarrying | 3.7 | 3.6 |
| III. | Food, drink and tobacco | 128.0 | 123.0 |
| IV. | Chemicals and allied industries | 93.9 | 80.1 |
| V. | Metal manufacture | 26.0 | 24.5 |
| VI. | Engineering and electrical goods | 462.8 | 407.0 |
| VII. | Shipbuilding and marine engineering | 10.8 | 8.1 |
| VIII. | Vehicles | 103.2 | 77.2 |
| IX. | Metal goods not elsewhere specified | 82.2 | 79.0 |
| X. | Textiles | 22.8 | 21.3 |
| XI. | Leather, leather goods and fur | 16.4 | 15.7 |
| XII. | Clothing and footwear | 128.4 | 109.7 |
| XIII. | Bricks, pottery, glass, cement | 36.8 | 29.6 |
| XIV. | Timber and furniture | 80.6 | 67.5 |
| XV. | Paper, printing and publishing | 195.2 | 173.5 |
| XVI. | Other mfg. industries (rubber linoleum, plastics, toys, etc.) | 72.3 | 64.2 |
| XVII. | Construction | 380.9 | 298.1 |
| XVIII. | Gas, electricity and water | 78.1 | 78.7 |
| XIX. | Transport and communication | 373.7 | 422.6 |
| XX. | Distributive trades | 663.6 | 625.3 |
| XXI. | Insurance, banking and finance | 240.0 | 255.2 |
| XXII. | Professional and scientific services | 431.8 | 462.7 |
| XXIII. | Miscellaneous services | 584.3 | 589.4 |
| XXIV. | Public administration and defence | 280.9 | 280.3 |
| | Other occupations | 22.3 | 22.6 |
| | Total | 4530.3 | 4326.2 |

If we look more carefully at the list of employment groups, the statistics can be assembled in three main groups.[1] The *Primary* (sometimes called *extractive*) group of occupations (Groups I and II) is unimportant and accounts for less than 0.3 per cent of the employed population. Market gardening and gravel-digging are the major representatives of this group.

1. The Standard Industrial Classification was modified in 1958; the three major groupings remain the same, but there are important differences in the numbering and specification of individual Groups, so that continuity of tabulation is impossible.

The *Secondary* or *manufacturing* industry groups (Groups III–XVI) include about 30 per cent of the total; the most important industries are engineering (including electrical goods), the paper and publishing trades, food-processing industries and the clothing trade. All these, it may be noted, are industries that have been growing nationally in the post-1918 period, and London is conspicuously lacking in the major occupations that have been declining as employers of labour, such as coal-mining, cotton textiles and agriculture.

London has long been a great centre of the *Tertiary* group of occupations or *servicing* industries (Groups XVII–XXIV), and these groups together employ 70 per cent of the employed population of the conurbation. This is not surprising in view of London's position as the capital city, exercising a national role in administration, banking and insurance, wholesale and retail distribution, and as the main centre of specialised medical, legal, educational, cultural and other services. Also, over 400 000, or nearly 10 per cent of the total employed population of Greater London, are engaged in the transport and communication industries. While the role of the port of London and the function of London as a railway centre are remembered, account must also be taken of the recent growth of London as an international focus of air routes. In any case, the task of transporting London's workers from home to work is itself one of great magnitude, for some 1.25 million travel each day from the suburban areas, and from towns outside London, to work in the centre.

The following table shows how the major groups have fluctuated since the First World War:

*Employment in Greater London, by industrial sectors* (thousands)

| | 1921 | | 1951 | | 1961 | | 1966 | |
|---|---|---|---|---|---|---|---|---|
| | TOTAL | % | TOTAL | % | TOTAL | % | TOTAL | % |
| Primary (Groups I, II) | 29.0 | 0.9 | 19.8 | 0.4 | 15.3 | 0.3 | 10.9 | 0.25 |
| Secondary (Groups III–XVI) | 1052.6 | 33 | 1522.6 | 35 | 1459.4 | 32 | 1280.4 | 30 |
| Tertiary (Groups XVII–XXIV) | 2089.5 | 65 | 2741.5 | 64 | 3033.3 | 67 | 3012.3 | 70 |

The Primary group has declined steadily, for more and more of London's market-garden land has been swallowed up, and gravel pits have either moved further out or become highly mechanised. The Secondary group rose to a maximum in the years after the Second World War, but since then the Government's policy of clamping down on industrial expansion in London and encouraging firms to move into the Development Areas has begun to take effect. Industrial Development Certificates issued by the Board of Trade have been increasingly hard to get in the London area; in (the years 1956–59 such certificates offered some 6.5 per cent of the country's

total new employment, but by 1964–67 this percentage had been reduced to 2. Thus between 1961 and 1966 every major industrial group showed a decline in employment.

The figures for the Tertiary group, however, the servicing industries, tell a different story. The continued growth of employment in central London is a phenomenon that has given rise to serious concern in respect of practical problems of congestion. Estimates suggest that in the late 1950s and early 1960s the number of office jobs in central London was increasing by at least

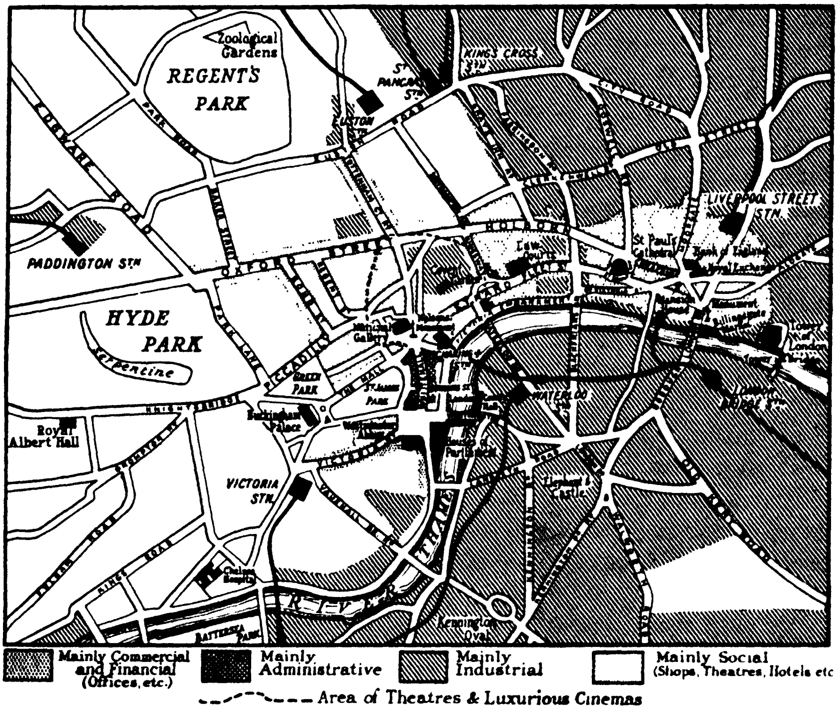



FIG. 234. The 'functions' of London

London is an excellent example of a large city in which definite areas are devoted to the main functions of the city. The blank areas are mainly residential.

15 000 a year. Whilst the growth of manufacturing industry is subject to control by the Board of Trade (and undoubtedly the Secondary group would have increased materially since 1945 had the natural inclination of industrialists been allowed to prevail) it is less easy to control the growth in the number of jobs in the servicing industries—and of course postwar reconstruction and the development of skyscraper office blocks in the City have helped to swell the employment opportunities. It is true that some restrictions have been imposed since 1963 on the rebuilding of office blocks in the centre, and further attempts have been made to decentralise office jobs to suburban centres and to New Towns and other towns situated

beyond the conurbation (see below, p. 687). Nevertheless the percentage of the total employment represented by the 3 million jobs in servicing industries continues to rise; and what is quite clear is that London must continue to develop as a service centre on an international scale.

## The industrial districts of London

In the years 1932 to 1938 inclusive out of 3635 new factories opened in Great Britain no less than 1573 were opened in Greater London; out of 2994 closed only 1055 were in Greater London. Taking the net gain in numbers of 641, no less than 518 were in Greater London, or 80 per cent of the whole of Britain. The outstanding feature in London itself was the general movement towards decentralisation. It must be admitted that the development of new factory areas in and near London was, in the main, haphazard. It is obvious that (*a*) labour supply, (*b*) space for expansion, (*c*) transport facilities, (*d*) relation to markets, and (*e*) water, gas, and electricity supplies and costs, and rates were leading factors.

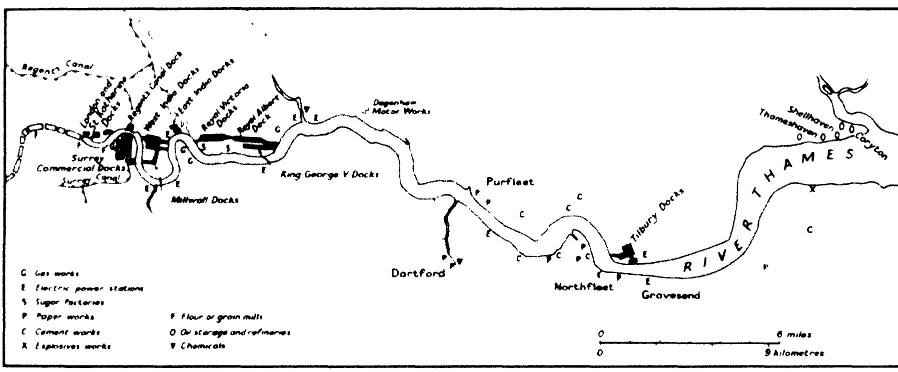



FIG. 235. The docks and riverside industries of the port of London

The small factory must needs be erected near an existing labour supply. But labour is mobile and a large unit, complete with housing scheme, can attract labour to itself. So there was the rise of new industrial centres, such as Letchworth (no less than 56 kilometres (thirty-five miles) from London), Welwyn (34 kilometres (twenty-one miles)) and, nearer in, Slough. There is a difference of opinion among manufacturers whether the factory to be erected near an existing residential tract should be on the outskirts so that the workers go *outwards* to their work, but have the amenities of town life at their doors, or whether the factory should be as central as possible and the workers come *inwards* to their work from homes where circumstances permit of small gardens for each. There is no doubt that want of space for expansion is by far the most important reason for moving an established industry. The modern mechanised factory requires a horizontal layout

rather than a vertical one, hence the great demand for space. In choosing the new site, transport facilities play a large part. For heavy and exporting industries (and for industries dependent upon bulky imported raw material) the importance of the nearness of the river or docks is paramount. This is very clear in the case of such industries as:

(*a*) Electric power works and gas works—using water-borne coal and practically all situated near the river. Those on the Regent's Canal now receive coal by rail or road.
(*b*) Cement works, an example of a heavy and exporting industry, using chalk, mud or clay and water-borne coal, all along the Thames below Dartford and the Medway.
(*c*) Paper works, petroleum refineries, grain mills, and sugar factories using bulky imported raw materials.

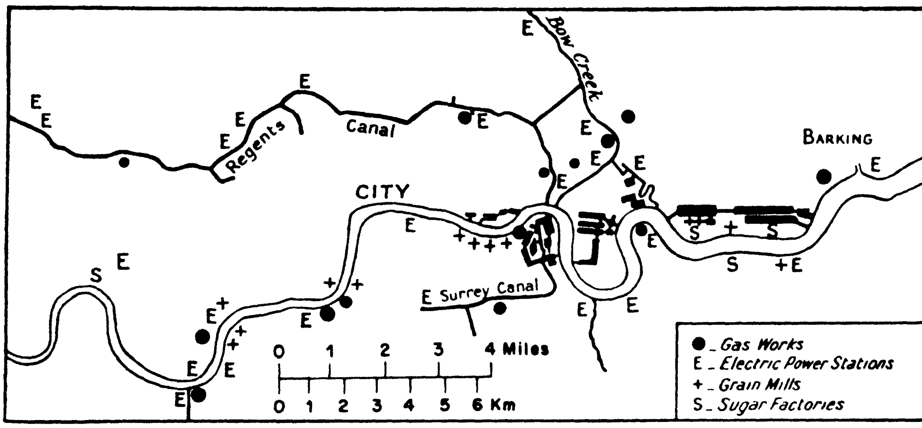



FIG. 236. Water-side industries of London

On the other hand, for lighter industries and those supplying primarily or largely the home market, nearness to the main railway lines or arterial roads is more essential. This is clearly exemplified by the almost continuous succession of factories built between the wars along the old Great Western main line from Ealing through Slough with such examples as the gramophone works (HMV) at Hayes, Middlesex, and the gigantic bakeries of J. Lyons & Co., Ltd, or the Park Royal Breweries of Arthur Guinness & Son, Ltd.

This separation of heavy and light industries fortunately operates to a considerable extent in another way. It coincides to some extent with a separation between 'dirty' or 'noxious' and 'clean' industries—to the advantage of residential areas. There is an element of danger associated with explosives and even with oil refining, with a consequent attempt to isolate them. Shellhaven and the great refineries on the Isle of Grain afford excellent examples.

There is, of course, another great factor at work where essentially skilled labour is required—the factor which may be called inertia. It operates in the clothing industry, which has expanded in the east and northeast of London rather than changed its location.

Mention was made above of the relation to markets. There are several points of view here. Those manufacturers who depend on the London area as their chief market must be near at hand for delivery; those who rely on London as an international mart and are manufacturing for export must be near both for shipment of goods and to permit foreign buyers to inspect their goods. A foreign buyer might well cut off from his list a factory whose warehouse was inconveniently far away for him to visit. The makers of bulky or standardised articles, of course, get over this by a showroom in London, but even then comes the difficulty that the buyer cannot talk personally with the principals of the business.

We list below the present industrial areas of Greater London:

## The East End

This traditional industrial area of London lies mainly in the former Metropolitan boroughs of Shoreditch, Bethnal Green, Stepney, and Poplar, together with those parts of West Ham comprising Canning Town and Silvertown. South of the river, Bermondsey may be included. Some medieval crafts long survived. There is still one bell-foundry and until the 1914 war there were silk-weavers at Spitalfields using hand looms as old in design as the industry itself. In the 1880s, when transport was entirely horse drawn or the docks reached by the sulphur-laden 'underground' of the Metropolitan Railway, shipbuilding was important along the river, ship repairing even more so. Shipbuilding is dead, ship repairing almost so, but to some extent modern engineering industries have grown out of the old shipbuilding, and the close connection with the sea is maintained by very large numbers of dockers and lightermen. Away from the river, furniture making, the clothing industry, printing and cardboard-box-making, tobacco industries, and food processing rank high. By number employed and value of output, London ranks first among the urban centres of Britain in many industries. Before the bombing and destruction of 1940–45 about a third of a million workers were employed in the East End. Shoreditch and Bethnal Green thus forms the 'city of the smaller trades and the lesser ingenuities'.

Since the nineteenth century clothing and furniture trades have clustered here. Furniture is still made in several hundred workshops in Bethnal Green and Shoreditch, where the small man often specialises in one process such as turning legs for tables, veneering or upholstery. The area produces a great variety of output but is no longer the metropolis of the trade. Stepney, especially Whitechapel, remains important in clothing manufacture principally the women's outerwear trades. Small workshops exist alongside fac-

tories with a few hundred workers, but mechanisation here scarcely extends beyond the electric sewing machine and some sectional division of operations. In recent decades clothing manufacture has spread to the decaying suburbs, notably Hackney and further afield into the Lea Valley and Essex. London does not to any appreciable extent manufacture textiles. The textiles required for the clothing trades are brought in from other regions to the factories or to wholesale merchants. Food, drink and tobacco industries are also important in the East End while printing works are clustered on the fringe of the City. Immediately beyond the Lea, in West Ham, is the principal area of chemical manufacture in London, which at one time 'benefited' here from laxer bye-laws on noxious industries.

While the home of leather tanning and the leather industry is in Bermondsey across the river, the manufacture of leather goods is by no means unimportant in the East End where, however, fur-dressing and furriery is particularly important. But what must again be stressed is the immense variety of miscellaneous industries—old crafts being found side by side with the manufacture of radio and television parts, or a range of plastic 'gadgets' inseparable from modern life.

### Soho and the West End

Behind the great shopping streets of the West End is a major concentration of the clothing industry concerned especially with outerwear for women. The factory or work room units are usually small, many concentrate on expensive garments.

### The Lea Valley

This is really an offshoot of the congested East End boroughs, from which population, soon followed by industry, began to move from 1880 onwards and the quiet fertile valley from Waltham Abbey southwards to Enfield, Edmonton, Tottenham, and Walthamstow was changed to a broad ribbon of small homes and factories. Up to 1914 the dominant industries were those of the East End—furniture, clothing, and metal working later followed a great diversification. Well served by waterways and rail, the later development came to rely more and more on road transport. In the Lea Valley the intensive production (under glass in heated greenhouses) of tomatoes, cucumbers, and flowers is organised as an industry rather than as a branch of farming, but necessitated the conservation of considerable areas of land for its use. Once it was good local soil, abundant water, and good sunshine average which attracted the industry, now proximity of markets and a large local labour supply are more important in retaining the industry, although it has declined in importance in recent years.

### The Lower Thames-side

This is London's heavy industrial area: in contrast with the areas just described it is essentially one of large units which have occupied the erstwhile marshlands. Examples are the great Ford works at Dagenham on the north of the river; cement works at Erith, Dartford, Northfleet to the south with the great oil refineries nearer the mouth of the river.

### West and Northwest London

With the exception of a few big pre-1914 firms at Willesden, Hayes and Southall, these areas grew up after the First World War, some parts indeed from munition factories, whilst much of the 1924–25 Wembley Exhibition grounds was given over to light industry. Industries are located in an inner zone or nucleus and in areas in four principal directions from the nucleus. Among the inner districts are Park Royal, Wembley Park, Acton Vale, Willesden and Cricklewood. Those on radial routes include (*a*) New Brentford and Feltham to the southwest along the Great West and Staines roads, (*b*) Hayes and Southall to Slough (actually to Buckinghamshire) along the former GWR line to the West, (*c*) Alperton, Perivale and Greenford along Western Avenue and the former GWR and LMS lines to the northwest, (*d*) along Edgware Road, e.g. Colindale; finally, (*e*) along the North Circular Road.

West London is particularly important in light engineering and vehicle manufacture and in the preparation of many types of proprietary articles, including branded foods and toilet preparations.

Rail freight is very significant for some districts, especially Park Royal and Southall. By contrast factories on Edgware Road depend mainly on road transport and the Wembley Park Estate makes little use of the rail facilities that surround it.

*Kingston bypass*, *Wandle Valley* and *Cray Valley* are three rather small and isolated areas of development south of the River Thames.

## London's wholesale markets

The covered retail markets of London, small and few, are insignificant when compared with the great covered markets of such towns as Liverpool and Birmingham. London's street markets are more comparable with the covered retail markets of the provinces, and play an important part in London life.[1] But London's wholesale markets occupy (or at least did prior to the outbreak of war in 1939) a unique position in that to a large extent they determine or influence prices throughout the country, and are an outward and visible sign of London's pre-eminence as a commercial centre. In a

1. See *New Survey of London Life and Labour*, iii, Chapter 13, p. 290.

very large number of commodities transactions are carried out by sample so that the 'markets' are or were merely certain streets in the City where firms specialising in certain commodities have their offices located. The tea market is or was in Mincing Lane, the jute market, sugar market, etc., near at hand. But in the case of foodstuffs where freshness is essential (meat, fish, and vegetables) the commodities are actually brought to the markets of the metropolis for sale.

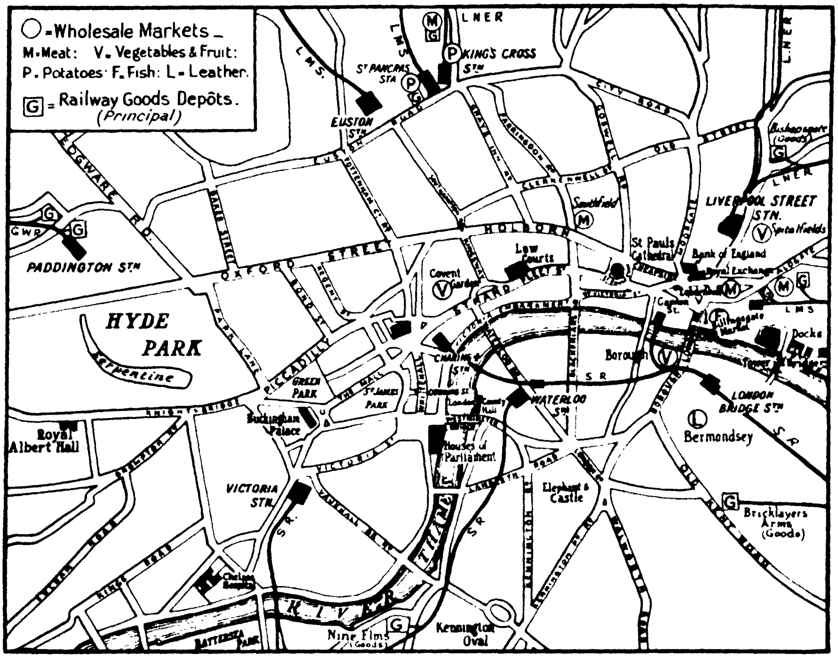



Fig. 237. London's wholesale markets
Shown in relation to the main railway termini and the docks

The City Corporation of London owns four markets: the London Central Meat Market at Smithfield, markets at Spitalfields, Billingsgate, and Leadenhall. Covent Garden is owned by a public company, two railhead markets have fallen to the control of British Rail. It is interesting that no markets were controlled by the London County Council which came really too late on the scene. Some of the markets, such as the LC Meat Market, serve mainly the London area; others, such as Covent Garden, serve practically the whole country, and there has been much discussion as to devising some means to obviate the delay and expense of repeated handlings necessary to bring such commodities as imported fruit to Covent Garden before reconsigning it to distant parts of the country.[1]

1. A South African farmer once told the writer that a case of oranges was handled fifteen times before it was opened in a retailer's shop in England. Five of these were necessitated by the existence of the Covent Garden system.

*Covent Garden.* Covent Garden is still the principal centre of Great Britain dealing in imported fruit and vegetables, and also handles a seasonal surplus of fruit from southeastern England. The market was founded in 1670 in the reign of Charles II. The market itself covers 2.3 hectares (5¾ acres) including open squares, covered market buildings and a Floral Hall where auctions take place. Most of the premises in the neighbouring streets are occupied by firms in the fruit and vegetable trade. The market is chiefly active between 3 a.m. and 6 a.m., when the homegrown supplies reach the market, and over 5000 vehicles go into the market in one day. It cannot be claimed that the market premises are up to date, and the congestion is notorious. There are active plans to move the market to a site at Nine Elms.

*Spitalfields.* The market founded originally in 1682 was long associated with the old fine silk industry of the area. It is now the market for fruit and vegetables, mainly from Essex and the eastern Home Counties supplying the populous east and northeast of London.

*Stratford.* This is a fruit and vegetable market adjoining, and constructed in 1878 by, the old Great Eastern Railway. It derives its supplies from the counties on that line. The railhead depots at King's Cross and Somer's Town had a similar function handling the potatoes and vegetables of the Fenlands in particular; while the Borough Market serves the south of London. Greenwich has also a small wholesale fruit market.

*The London Provision Exchange.* Established in 1887, this market normally handles the whole of the bacon and ham imported into London—about half of the total imports of the country. It is concerned also with butter, cheese, lard, and canned goods.

*Smithfield.* The London Central Market, owned and operated by the Corporation of the City of London under a charter of Edward III, covers now an area of 4 hectares (10 acres) and is the principal meat market, dealing also in eggs, poultry, game, butter, and cheese. From the point of view of ease of approach and facilities for handling the meat, Smithfield is the best of London's markets: 60 000 sides of beef (about 9000 tons) can be displayed at once; there are external loading points for 350 three-ton lorries at one time and thirty-one ample gates to the market itself. There are numerous cold stores adjacent to the market. The incoming lorries deliver their loads and are away between 4 a.m. and 6 a.m. The retail butchers do most of their purchasing between 6 a.m. and 8 a.m.

*Leadenhall Market.* Handles mainly poultry and, being not far from Billingsgate, is convenient for retailers who sell both fish and poultry; though more poultry is being handled at Smithfield. There is also an important retail market.

*Billingsgate.* Billingsgate fish market more than rivals Covent Garden in historic interest. It is the oldest of the markets controlled by the City Corporation, and its site—by the riverside around a small haven just below London Bridge—was inevitable when most of the supplies were waterborne. Actually the proportion of waterborne deliveries has now dropped to a small fraction of the total, and the bulk has therefore to be brought from the great railway termini. Although the market serves primarily London and the southeastern counties, not a small proportion is conveyed to distant points in the south—possibly not far from where the fish was originally landed. The market itself, with an area of about 0.5 hectare (an acre), is unable to accommodate the quantity of fish to be sold. Thus much of the selling is by samples, and delivery can be made from the railway companies' vans which line the 'Inner Circle' of streets surrounding the market direct to the waiting buyers' vans which line the 'Outer Circle' of side streets. The market opens at 5 a.m. when deliveries arrive from the special night fish trains. Retailers arrive at 6 o'clock and most of the business is over by 8 a.m. and the streets clear before the great throng of city workers pours through the neighbouring thoroughfares at 9.0 or 9.30.

The other markets are indicated in Fig. 237. The old Hop Exchange was off the Borough.

## London during the Second World War

London was so obviously the nerve centre of Britain and the Commonwealth that it was reasonable to presume an immediate massed air attack in the event of war. Consequently, when war broke out in September 1939, prearranged plans for the evacuation and the setting up of autonomous Civil Defence Regions covering the whole country, as well as the dispersal of commerce and industry, were immediately put into effect. The serious attack did not in fact come for nearly a year, but in the winter of 1940–41 nightly raiders caused much damage, especially by incendiary bombs. Dockland, the East End and parts of the City suffered severely. After April and May there was something of a respite until the advent in the later stages of the war of the guided missiles (flying bombs, or V1s), and then the giant projectiles, or V2s, with great destructive power. Although large numbers of evacuees, including children, had drifted back to London, London's normal activities remained greatly reduced. The Port handled but a fraction of its prewar volume of trade, many of the City's commercial and business firms carried on from addresses scattered widely through the country, few industries of national importance continued to function in London. Even so, shops, restaurants, hotels, cinemas, and theatres carried on and because many businesses did not do more than move from the centre to the suburbs the population of Greater London probably never dropped below two-thirds of its 1939 total. That of the County of London reached a low of 2 314 700 in December, 1941, compared with 4 062 800 in mid-1938.

## London after the Second World War

The end of the war was marked by an immediate rush to return to London—of individuals, of business and commercial houses, of industry and even of Government departments. Decentralisation, previously advocated as desirable, necessitated by the war, had proved to have many disadvantages. Although careful and imaginative plans had been prepared for the rebuilding of city, county, and suburbs, it was difficult for several reasons to put these into effect. Bombing had resulted in spasmodic rather than systematic clearing of large sites, and the shortage of houses was so acute that any dwelling which could be repaired and made habitable had to be so used, thus postponing demolition of obsolescent buildings indefinitely. Priority of labour and materials had to be given to housing, and work on large office blocks, as well as hotels, cinemas, department stores, and other 'luxury' work, even including factories and warehouses, had to take second place. By 1952 scarcely a start had been made on rebuilding the City. On the other hand, the expansion of the civil service to staff such new ministries as Food and Defence, Housing and Local Government and to take care of nationalised industries—such as coal and transport—involved the spread of Government offices to many parts of London. In some cases, as in the east side of Regent's Park, their use as Government offices saved much of Regency London—houses which private occupiers could no longer afford to maintain. With the destruction of some large shopping areas, the remaining areas had become much congested, and shops and offices have still further invaded the formerly residential areas, notably Mayfair. The westward migration of varied light industries became more marked, partly because of the relatively slight war damage when compared with the East End. Shipping and trade returned to the London docks and the influence of water transport is still strong enough to concentrate the development of power stations and oil refineries on Thames-side and an expansion of the great self-contained vehicle plant of Ford at Dagenham.

## The future development of London

Modern London illustrates in a remarkable way the separation, which is characteristic of most of the very large modern centres, of areas serving each of the five great functions of a city: the commercial, the administrative, the industrial, the social, and the residential. As a result of the destruction wrought by bombing in 1940–45, the areas have become less clearly defined and the expansion of central administration in particular has caused Government offices to appear in most unexpected places. Normally the heart of commercial London is the City with its banks, its insurance houses, its business premises, its warehouses, and its markets. On the one side to the east it is very closely linked with the Port of London. Much of the buying and selling is actually done by samples in the City whilst the goods them-

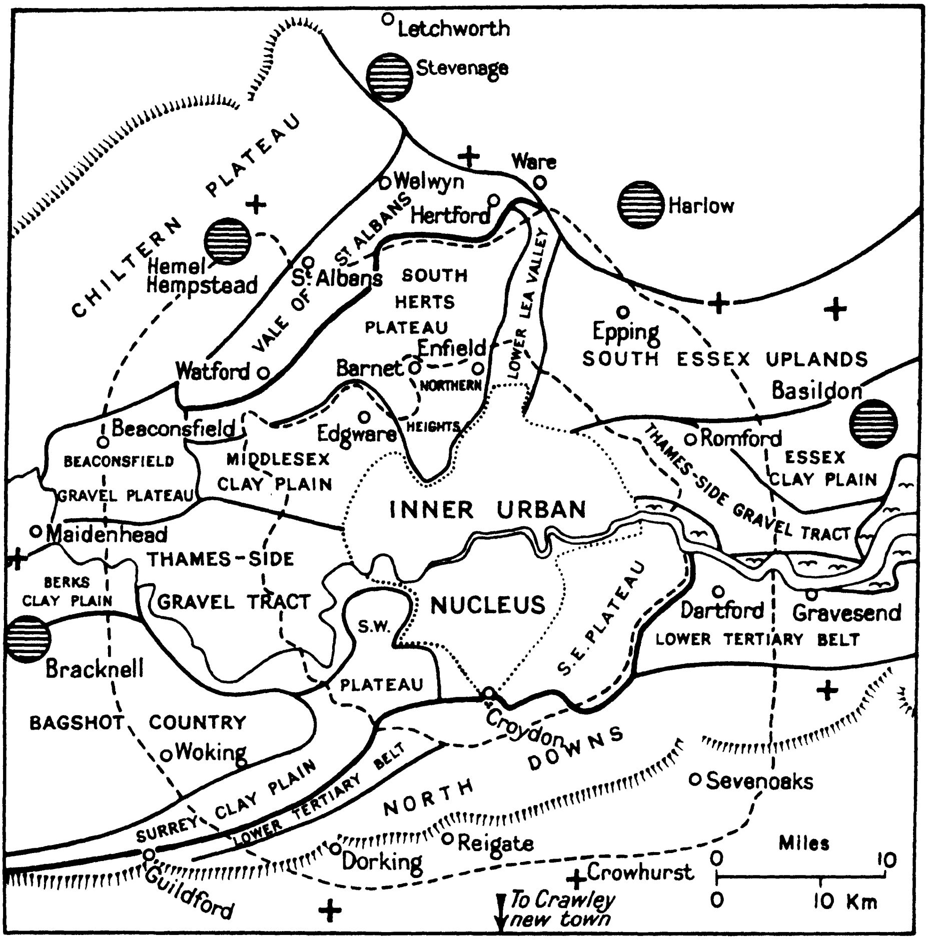



FIG. 238. Greater London in relation to the surrounding physical regions (after S. W. Wooldridge, *Trans. Inst. Brit. Geog.* 1946)

Crosses: sites proposed for new or satellite towns in the Greater London Plan of 1944. Circles: new towns. Hatfield, Welwyn Garden City not shown

selves remain in the Port. The growth of commercial London was driving out the resident population in many western areas long before the outbreak of war in 1939. Bush House is outside the city limits. The replacement of old buildings on the South Bank by the giant Shell Centre (1962) is another indication of the spread of commercial London. Social London remains in the West End. Here in juxtaposition are the theatres, the cinemas, the large stores, and attractive shops, the clubs, restaurants, and hotels within reasonable access to the principal railway termini; but new building is mainly of office blocks.

A question brought very much to the fore is whether London should be *allowed* to grow. Between the wars more than 10 000 new factories were

built. The transport of London's workers from their homes to their work threatens to become an insoluble problem despite the coordination of transport services (especially under the London Transport Executive) and schemes for further railway electrification.

Consequently the London Plans emphasise physical limitation by a green belt and accommodation of 'overspill' population in self-contained New Towns 30 to 80 kilometres (twenty to fifty miles) from the centre. In the meantime the concept of the 'neighbourhood unit'—a town within a town —has grown, though it merely crystallises the old local allegiance denoted by such neighbourhood names (they are not administrative units) as Bloomsbury, Mayfair, Belgravia, and Chelsea. If people *want* to live in London should they, in a free society, be prevented?

In accordance with this policy the building of a ring of New Towns was undertaken. Some are shown in Fig. 238—Crawley in the south, Bracknell in the west, Hemel Hempstead, Welwyn, Stevenage, Hatfield and Harlow to the north, Basildon to the east in Essex.

The original population of the areas designated as New Towns was 98 500; in December 1968 it was 450 000 and it is expected to rise to about 642 000. A main characteristic of the New Towns is the provision of industrial employment as well as residence. By 1968 there were over 100 000 jobs in manufacturing in the eight towns, mainly in the expanding industries such as electrical goods, engineering, vehicles, chemicals, and food and drink industries.

In addition there has been a planned decentralisation to towns that have been expanded under the Town Development Act, 1952. No less than twenty-seven schemes have been agreed between London and such towns as Ashford, Basingstoke, Bletchley, Haverhill, Swindon, Thetford and Wellingborough. By 1967, 29 378 houses had been built under these schemes and 410 firms had moved to 'expanded' towns. Attempts have also been made since 1964 to control the growth of office employment in central London, and to decentralise office employment to the suburbs and to New and 'expanded' towns. Over and above the planned movement of people and jobs from London to other parts of the region there has also been a substantial 'voluntary' outward movement to 'commuter' areas beyond the conurbation. The Metropolitan Area extending outwards from the edge of the conurbation for about 40 kilometres (twenty-five miles) (i.e. to some 64 kilometres (forty miles) from central London) grew by 800 000 between 1951 and 1961 and the tendency has continued. It is expected that the total overspill from the conurbation will be about one million in the period 1966–81.

Estimates of future population growth suggest that, while the population of the Greater London Conurbation may fall slightly by 1981 there may be a growth of 2.14 million people in the South East Region between 1964 and 1981. Differences of view exist on the planning strategy to be adopted. The *South East Study* (1964) advocated a second generation of new and expanded

towns of larger size than the first New Towns. Not all its proposals have been accepted although plans for the new town of Milton Keynes, near Bletchley, are well advanced. *A Strategy for the South East* (1967) put forward suggestions for the development of 'sectors' following the main radial routes out of London and including a number of major expansion schemes large enough to serve as foci of counter-attaction to London itself. But new proposals for planning the London region were expected late in 1969 from a study being made by the Ministry of Housing and Local Government.

# 27
# The growth of communications

The history of the development of facilities for communication in the old-established and highly industrialised country of Britain is a subject so vast, and withal so well supplied with literature,[1] that in this chapter, fascinating though excursions into economic history might prove to be, we can scarcely hope to present more than a brief essay in the geography of transport and an analysis of the relative importance of geographical and other factors in influencing the growth of roads, canals, and railways.

Two features of fundamental importance have played a part in modelling our present transport system. In the first place, one may say that Britain is, on the whole, by its physical nature, well favoured for the development of two out of the three major modes of communication—road and rail. There exist very few real barriers to road construction in the shape of high mountain ranges or wide marshes, and the 'negative' areas are of such small extent that both roads and railways can round the obstacles without long detours. The all-important raw materials, both for road making and for the road beds of railways, are widely distributed (cf. p. 363), and railways were, in addition, favoured by the existence of fuel supplies of excellent quality—a fact which had no little influence on British locomotive design and practice. For canals, however, the undulating surface of Britain, with its industrial regions separated for the most part by upstanding areas of harder rock or by alternating scarps and dip-slopes, is not nearly so well adapted as, for example, the flat plains of the Netherlands and North Germany, whilst long navigable rivers free from vexatious sinuosities are non-existent. Although Britain passed through a canal era of great importance in its industrial development, it is not surprising that this form of transport should have seriously declined with the rapid expansion of railways.

Secondly, a characteristic feature of the development in Britain of railways, canals, and the 'turnpike' roads has been the dominance of private enterprise and the virtual absence, from the Roman period until quite

1. See References, p. 831; standard works are Jackman, *Development of Transportation in Modern England* (a solid and well-documented piece of research); and Pratt, *History of Inland Transport and Communication in England* (a more popular and more readable account). Also Appleton, *The Geography of Communications in Great Britain*.

recently, of Government assistance.[1] This strict adherence to laissez-faire principles, with its preservation at all costs of open competition, lest a dreaded 'monopoly' should come into being, has been responsible for many of the difficulties of the present transport system, and for many of the differences which exist between Britain and Continental countries. There was no national plan, as in the case of the railways and 'routes nationales' of France; instead, the systems grew during periods of boom—the canal 'mania' of the 1790s and the railway 'mania' of 1845–47—in haphazard fashion, and sometimes without either sound geographical basis or real economic need. Turnpike trusts were established in large numbers, in many parts of the country, with little reference to the economic needs of the period; canals—long since derelict—were constructed through areas where neither through nor local traffic could reasonably be expected to yield a profit. Some of the early railway lines were similar; others were constructed merely to act as competitors to already existing lines.

With these preliminary considerations in mind, we may attempt very briefly to trace the history of transportation in this country.

## Roads

The Roman roads, military in origin and well planned and constructed, were for the most part stone causeways following a straight course from beacon to beacon across the higher and more open ground above the forests and marshes of the lowlands.[2] Even at this early stage the importance of London as a focal point was well marked (cf. Fig. 211). For a long period after the departure of the Romans little attention was paid to communications, and although many improvements were made in the thirteenth and fourteenth centuries conditions of transport subsequently deteriorated considerably. Rivers were undoubtedly more important than roads, and nearly every town of any size was a river port (e.g. York, Lincoln, Gloucester, Chester) (cf. Fig. 223). The accessibility of the university towns of Oxford and Cambridge was certainly improved by the waterways of the Thames and Cam. Towns such as Birmingham and Bradford, not on navigable streams, were non-existent or of no consequence.[3] The medieval roads were mere trackways, the actual route of which was constantly shifting to avoid the more dilapidated patches.[4] There was but a meagre demand for intercommunication between towns and villages when subsistence agriculture

1. Note, however, the military roads of the Scottish Highlands, constructed in the eighteenth century by General Wade and his successors, and the costly but rather useless Caledonian and Crinan Canals built with Government money.
2. See Ordnance Survey Map of Roman Britain.
3. Birmingham remains an example of one of the very few large towns in the world actually on or near a water-parting.
4. This continual departure from a direct course may possibly explain some of the curious sinuosities in the present-day roads.

and domestic industry were the rule, and the upkeep of the roads was regarded as a charitable occupation and so left mainly to the monks. With the breakdown of the manorial system, the decline of the fairs and the cessation of pilgrimages, and, finally, the dissolution of the monasteries, the roads grew worse and worse. An Act passed in 1555 delegated the labour of road mending to the parishes. This measure actually remained in force until 1835, but it really cannot be said to have succeeded in greatly improving the road system, for the statutory parish labour was easily evaded and the methods employed were of the most primitive order. There was still no pressing need for efficient roads until the trade of the country, both internal and external, began to expand in Elizabethan times. The fairly late introduction of industry into Britain, when compared with certain parts of the Continent, is largely due, in fact, to the difficulties of internal transport.

The increase of wheeled traffic played havoc with the layers of mud and stones which passed as roads in the seventeenth century. Long covered wagons had begun to be used in the sixteenth century, and stage coaches made their appearance fairly early in the seventeenth century, and the result was a series of regulations concerning weights to be carried and width of wheels, it being thought that wide rims would cut up the roads less than narrow ones. The legislation, it should be noted, was concerned with adapting the vehicles to the roads, not with improving the roads to accommodate the vehicles. Descriptions of roads and journeys during this century and a half (1600–1760) are numerous and entertaining. The Tours of Defoe[1] and Young have been previously referred to in this book. It was indeed an adventure almost equivalent to a modern crossing of Central Africa to undertake a long journey through Britain, and it is little wonder that those who performed such travels wrote at great length of their experiences. The many clay belts of England were areas of especial difficulty. In the winter the roads across these regions were almost impassable, and the sparse settlements were isolated for months on end. Of particular ill-fame were the roads across the Weald Clays of Sussex, across the London Clay, Gault, and Oxford Clay belts which intervene between London and the Midlands, and across the bogs of South Lancashire. Heavy lumbering carts with their numerous horses cut the roads into deep ruts, and the laying of stones only served to make progress more dangerous and uncomfortable for travellers on horseback or in wheeled vehicles. Of the road to Wigan, Arthur Young says: 'I know not in the whole range of language terms sufficiently expressive to describe this infernal road . . . eighteen miles of execrable memory'. Obviously industrial development was not aided by such conditions, and south Lancashire and the Birmingham region, especially, found themselves hampered by the difficulty of disposing of their goods. Road speeds, too, were extremely slow. In the middle of the eighteenth century, Edinburgh

1. See especially Appendix to vol. ii of Defoe's *Tour thro' the island of Great Britain* (original edition, 1724–26).

was 10 to 12 days' coach journey from London, Exeter 4 days, Birmingham and Dover 2 days, and so on. It was with the object of improving road conditions that the Turnpike Trusts were set up. The first of these was instituted in 1663 on a section of the Great North Road in the clay belt between Hertfordshire and Huntingdon; their object was to obtain money for maintaining the roads in good condition by charging tolls. About 1100 separate trusts were formed, the greatest period being 1760–75; but many of them controlled only a few miles of road, and large numbers were thoroughly inefficient, most of the tolls going towards the payment of trustees' salaries. There is no doubt, however, that the turnpike movement did an enormous amount of good for road transport, especially after the advent of new methods of road making. Until the beginning of the nineteenth century the construction of roads was not regarded as an occupation worthy of the skill of engineers, and, as we have seen, the authorities tried in vain to adapt the traffic to their poor surfaces. Between 1810 and 1820, however, two men, Telford and McAdam, began to apply scientific principles to road building; Telford, who commenced reconstructing the Holyhead road in 1815, concentrating upon the creation of a solid foundation and adequate draining; McAdam, who attained the position of Surveyor-General of Roads in 1827, devoting his attention to the production of the durable, impermeable surface which still bears his name.[1] A great impetus was thus given in the 'twenties and 'thirties to the development of coaching traffic. Just when the Turnpike Trusts were beginning to set the roads of Britain in good order a new form of transport, the railway, entered the field and deprived them of much of their revenue. During the second half of the century they were all wound up, the control of the roads passing into the hands of Parish Councils and Highway Boards, and later into those of the reconstituted Local Government bodies, County, Borough, Urban, and Rural District Councils. Thus road transport for several decades became a matter of local importance, until the evolution of the petrol motor rendered the construction and maintenance of roads of first-class national significance.

## Rivers and canals

The age of bad roads, in the seventeenth and eighteenth centuries, is marked by an increased attention to river navigation. The natural waterways had been for so long neglected that their beds had become silted up, and disastrous floods occurred after periods of heavy rainfall. Thus, many medieval ports, such as Lewes, Ely, Bawtry, York, and Doncaster, had been deprived of their position and had lost in trade and importance thereby.

1. The essential point of his work was the discovery that stone broken to a uniform size and of angular shape could be made to bind together. The tarring of the pieces (and the making of tar-macadam) with the consequent elimination of dust, is a twentieth-century development. The reinforced concrete road has gone still further to solve the problems of roadmaking in country with a soft subsoil.

The first Act for improving a river was actually passed in 1424 concerning the River Lee (an important highway for London's wheat supply), but the great age of dredging and artificial cutting (to avoid the frequent meanders) was between 1660 and the beginning of the canal era. Although rivers all over the country were subjected to much improvement, the greatest incentive came from the north of England, where industries were beginning to develop rapidly. Thus the Mersey was improved as far as Warrington in the 1690s, and in 1720 three new projects were sanctioned—the Mersey and Irwell navigation, giving navigable water as far as the growing town of Manchester; the Weaver navigation, opening up the Cheshire salt-field; and the Douglas navigation, providing an outlet for the Wigan coalfield to Preston. The Aire and Calder navigation, commenced in 1699, stimulated the growth of Leeds and Hull, and the improvement of the Don enabled the manufacturers of Sheffield to obtain their Swedish iron more easily.

The various disabilities attaching to river navigation, however, such as time wasted in following the innumerable windings, the difficulty of towing upstream, and the fluctuation in depth of water according to season, together with the fact that several growing industrial areas, such as Birmingham and the Potteries, were not served by navigable rivers, led to the development of artificial waterways or canals. The link between the two is the Sankey Canal, sanctioned in 1755 as a river improvement scheme to provide an outlet for the Wigan coalfield. The improvement of the Sankey Brook being found impracticable, an entirely artificial cut was made. From this small beginning an extensive canal system came into being within the next sixty years. The canals were built by private enterprise, competing with the Turnpikes, and the companies were modelled on the lines of the Trusts, that is, they were toll-takers, and not carriers. As a result, there was great variation in depth and width, size of locks, and gauge of tunnels, etc., and through long-distance traffic was compelled to pass over the property of several different companies.[1] At first, however, the improvement in speed upon road transport, the reduction of freight rates to about a third or a quarter of the amounts charged on the roads, and the ability of the canals to carry bulky raw materials and finished goods in hitherto inconceivable quantities sufficed to enable many of the canals to pay enormous dividends.

Geographical influences in the growth of the principal elements in the canal system—if it can be called a system—are very evident. The increasing use of coal in industry and as a household fuel, together with the industrial development of the Midlands and North, where the roads were particularly bad, were responsible for the greater part of the canal cutting taking place in those areas, whilst the South was left—with one or two exceptions—comparatively untouched. The Black Country, South Lancashire, and the West Riding became the principal foci, London, with its river navigation

1. For example, Birmingham to Liverpool, six canal companies, each canal of different dimensions; Liverpool to Hull, ten companies.

and coasting trade, being distinctly ex-centric in marked contrast to its position as regards the roads and later railway nets. In Lancashire and Yorkshire three needs were being catered for: (*a*) more adequate disposal of coal; (*b*) easier transport between the cotton and woollen centres and the coast; (*c*) coast to coast communication, in order to avoid long coastal voyages. Thus, the Worsley Canal linked the Duke of Bridgewater's collieries with Manchester, the Bridgewater Canal gave the cotton capital a new and better outlet to the Mersey estuary, and the Leeds and Liverpool Canal, and also the Rochdale and the Huddersfield canals, linked the navigable waters on either side of the Pennines. The Leeds and Liverpool Canal, especially, was responsible for much new industrial development in the Aire valley and in the valleys north of Rossendale Forest. The great canals of the Midlands fall into two groups. In the first place there is the complicated system in the Birmingham–Black Country region, which afforded much-needed outlets for coal and the bulky produce of the iron and other metal industries; secondly, there are the canals designed to link up the major navigable rivers. Of these the most important were the Grand Trunk from Trent to Mersey, which had a truly remarkable effect upon the development of the Potteries, where Wedgwood had just recently (1763) begun his improvement of the staple industry (cf. p. 603); the Shropshire Union, linking the Birmingham system with the Mersey; the Staffordshire and Worcestershire, linking the Birmingham system with the Severn; the Grand Junction, giving navigable water from London to Birmingham and the Trent; the Thames–Severn (across the Cotswolds to Stroud) and the Kennet–Avon. These interriverine canals were instrumental in displacing a great amount of coastal sailing; when coasting steamers developed they lost most of their traffic, and the last two, for example, have long been disused. South Wales also developed canals as an aid to its iron and coal export trade—the Monmouthshire and Glamorganshire valleys providing obvious lines of movement to the ports of Newport and Cardiff. It is noteworthy, however, that Northumberland and Durham—the home of wooden and iron tramways (see Chapter 14 and below)—never adopted a canal system. In Scotland the Forth and Clyde Canal from Bowling to Grangemouth had as its primary object the connection of the coasting trades of east and west Scotland;[1] but the Monkland Canal (from Coatbridge to the Forth and Clyde Canal at Glasgow) and the Union Canal (from the same canal at Falkirk to Edinburgh) were both constructed to give outlets for the Lanarkshire coalfield. The state-aided Caledonian and Crinan Canals (the former from Fort William to Inverness and the latter across the head of Kintyre) have never been of any real economic importance.[2]

1. Its western terminus was 16 kilometres (10 miles) below Glasgow, owing to the shallowness of the Clyde. It was finally closed about 1963.

2. Even modern pleasure steamers start from above the famous 'Neptune's staircase' of locks at the southern end of the Caledonian Canal. The British Waterways Board's cruiser carried 12 000 passengers in 1967.

The great boom in canal construction came between 1791 and 1794, during which period eighty-one new canal and navigation Acts were passed. Many of these were for quite useless canals which either soon went out of business or became absorbed in the larger concerns. The coming of the railway after 1830 was the beginning of the end for a large part of the canal system. In that year the British Isles possessed 6872 kilometres (4270 miles) of canals and inland navigations (i.e. improved rivers), over 5150 kilometres (3200 miles) in England and Wales, nearly 322 kilometres (200 miles) in Scotland, and nearly 1368 kilometres (850 miles) in Ireland. By reason of the great industrial expansion of Britain, traffic on many of the canals actually increased until the end of the century, but the total canal traffic was very small beside that carried by the railways.[1] We may profitably summarise the principal reasons why the decline of the canals has taken place and why their resuscitation is impossible.[2]

1. The narrow canals and rivers of Britain are ill adapted for speedy carriage, for fast-moving vessels create a wash which would quickly undermine the banks.
2. Britain is not physically suited to canals. Locks are required in great number and tunnels (the older ones without towing paths) are not infrequent, and the resultant delays add considerably to all journey times. Between London and Avonmouth, for example, in 286 kilometres (178 miles), there are 125 locks (including a remarkable 'staircase' of 29 at Devizes); between Liverpool and Hull, 256 kilometres (159 miles), there are 147 (92 in 51 kilometres (32 miles) over the summit of the Rochdale Canal); between London and Birmingham *via* Blisworth, 159 locks in 217 kilometres (135 miles); and between Birmingham and Sharpness 62 locks in 121 kilometres (75 miles). At Anderton (near Northwich) a hydraulic lift raises barges 15 metres (50 ft) from the River Weaver navigation to the Trent and Mersey Canal.
3. A large part of the canal system is of small dimensions, incapable of taking boats drawing more than 1.2 metres (4 ft) of water, or more than 2.1 metres (7 ft) in width. Narrow canals are especially characteristic of the Birmingham system, on which special narrow boats must be employed.[3] The impossibility of widening these canals is evident when it is realised that over much of their extent in the Black Country the banks of the waterways are completely built over with factories, works, and even dwellings,

1. 1898: Canal traffic 39 million long tons; railway traffic 379 million long tons. These are 'unreal' figures, since traffic passing from one company to another was recorded by each company and so may figure several times in the total. However, the truth of the generalisation made above is apparent.
2. See Royal Commission on Canals and Inland Navigation, Cd. 4979, 1909, also E. A. Pratt, *Canals and Traders*, which sets out clearly the arguments against the revival scheme proposed by the Commission.
3. It is not the open channels of the canals which are narrow, but the locks and bridges, which it would be very difficult and costly to widen.

many of which, though possibly owing their site to the facilities for water transport, now make little or no use of them.

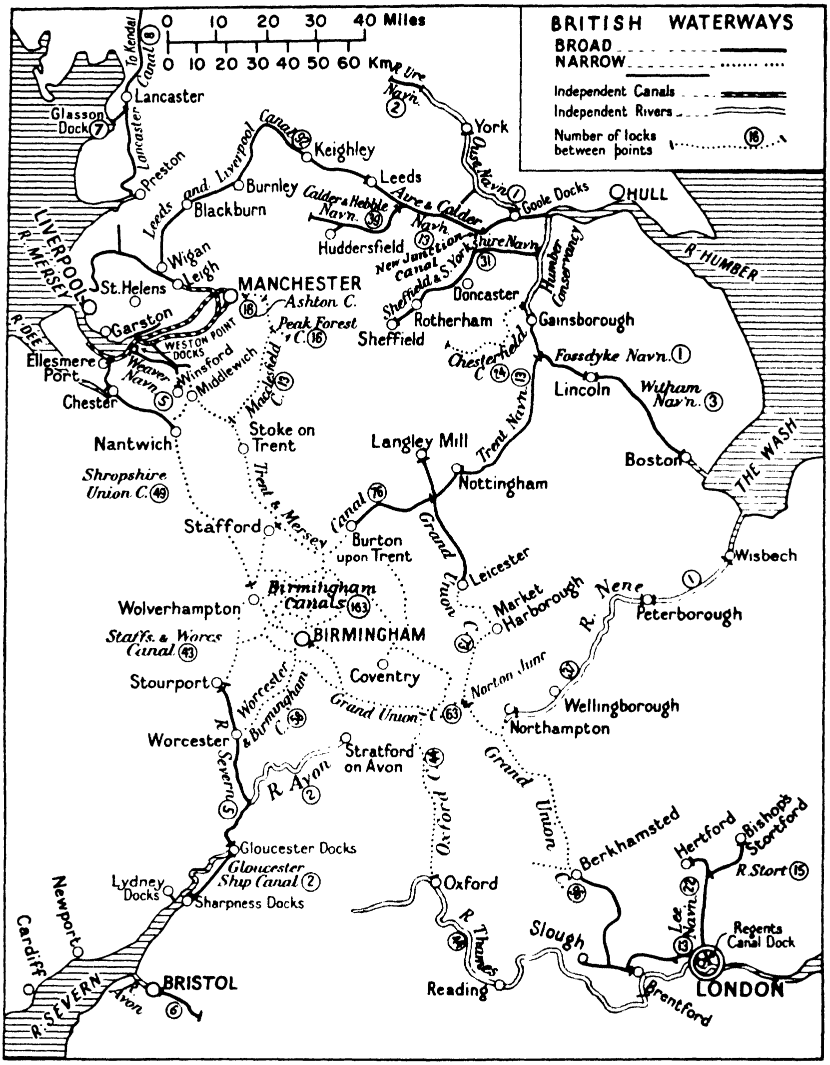



FIG. 239. Navigable waterways of England and Wales, 1959
The new junction canal, in Yorkshire, joins those to north and south.

4. Many canals, designed to facilitate coal transport, pass through coal mining areas in which ground subsidence is of frequent occurrence, and the maintenance of the waterway consequently difficult. Thus, in the Black Country, in Lancashire, and in the Potteries, subsidence has occurred to such an extent that the canals now run in places above the general level of the land, like an embanked river over its floodplain.

5. Canals which cross watersheds are likely to experience difficulty in obtaining adequate water supply. Were such canals to be enlarged, great reservoirs would need to be constructed in order to render navigable the deeper and wider channels.
6. The great disadvantage of the canal is its lack of flexibility and its capacity for serving adequately only those factories, mines, and farms which lie along its banks. Owing to the initial cost and difficulty of construction, a canal is very much less flexible than a railway. Canals, moreover, are not well adapted for carrying small loads to a number of different points, and in any case only short haulages are possible, owing to the small size of the country.

Fig. 239 shows the navigable waterways existing in 1959—with an indication of the number of locks. They may be divided into three classes: first, the 'open' river navigations (such as the Crouch, Hull and Wharfe) totalling 200 kilometres (124 miles); secondly, the independent waterways (most of the navigable rivers, the Manchester Ship Canal, and canals that are in fact mainly used for drainage, as in the Fenland) amounting to about 2736 kilometres (1700 miles); thirdly, the canals and river navigations under the control of the British Waterways Board, totalling just over 2575 kilometres (1600 miles). British Waterways traffic totalled 12 million long tons in 1953 and 9 million long tons in 1963, and the decline continues, particularly since the National Coal Board ceased to use water transport in 1965; in 1967 the total was just over 7 million long tons. About 20 per cent of the waterway system carries 90 per cent of the traffic, and the principal remaining waterways are the River Trent (below Nottingham), the Aire and Calder, the Sheffield and South Yorkshire, the Calder and Hebble, the Fossdyke, the river Weaver, the Berkeley Canal, the River Lee (below Enfield), and the southern end of the Grand Union Canal (below Uxbridge). The greater part of the canal system now carries little commercial traffic, though it remains of great potential value for amenity purposes—boating, crusing and fishing—and parts of it are valuable for water supplies or drainage.[1]

## Railways

Just as the canal system owed its origin to the growing dissatisfaction with the bad roads of the eighteenth century, so a large part of the railway system grew up in the first place to supplement the inadequate services provided by the waterways, and to introduce better transport into those areas where canals had not penetrated. Once again we find that private enterprise was responsible, and the result was a haphazard growth almost completely devoid of plan or any suggestion of a possible national system. Fortunately,

1. In 1967 the British Waterways Board issued over 10 000 licences for pleasure craft; and on a June Sunday a census recorded 27 000 anglers fishing in the canals and reservoirs!

however, with one major exception, the companies all adopted the standard gauge of 1.435 metres (4 ft 8½ in). The exception was the old Great Western which used a broad gauge until the 'nineties. Parliament, moreover, did all it could to promote competition and prevent any line from having a monopoly of traffic. Railways in Britain were regarded as dangerous innovations, to be resisted alike by turnpike trusts, canals, and landowners, and the result was that from their very beginning they were hampered by excessive costs—heavy legal expenses in order to overcome opposition to the passing of their bills, and exorbitant charges for land.[1]

To an even greater extent than that of the canals, the early history of the railways is bound up with the coal trade. Long before the invention of the locomotive, wooden, and later iron, tramways had been utilised in the Northumberland coalfield for transporting coal from the mines to Tyneside (cf. Fig. 119), and similar systems arose in Shropshire and in South Wales. The Tyne had for centuries been an avenue for coal traffic, and the increasing distance of the collieries from the river was not easily bridgeable by canals, owing to the nature of the land surface. In South Wales, too, away from the main valley bottoms, canals were virtually impossible, and thus an extensive system of tramways grew up around Merthyr Tydfil and between that town and Cardiff. Between 1801 and 1825, when the first real 'railway' was opened, no less than twenty-nine 'iron railways' were constructed in various parts of the country, mostly connected with canals, ironworks, or collieries.

The influence of the coal trade upon the early railway system may be gauged from Fig. 240.[2] The Stockton and Darlington line, the first public railway, was intended to provide an outlet for coal from Witton Park to the Tees, and its promoters had no intention of carrying passengers. A network of lines quickly developed in the northeastern area, linking the collieries with the mouth of the Tyne and with the ports of Sunderland, Hartlepool, Stockton, and Port Clarence. In the Scottish lowlands the earliest lines (Monkland and Kirkintilloch; Glasgow and Garnkirk) were built to connect the Lanarkshire coalfield with the Forth and Clyde canal and with the port of Glasgow; in South Wales the Llanelly railway and the Taff Vale lines were likewise developed to facilitate coal movement; and the Leicester and Swannington line was designed to carry coal from the Leicestershire coalfield to the county town at a cheaper rate than that charged by the Soar navigation from Derbyshire. In Lancashire the inability of the existing system of waterways to accommodate the vastly increased traffic between Liverpool and Manchester engendered by the cotton industry was mainly responsible for the step taken by a group of merchants in promoting the Liverpool and Manchester railway, opened in 1830, but several subsequent

1. The London and Birmingham, for example, paid £72 868 in legal costs, and an average of £6300 per mile for land. See Pratt, *History of Inland Transport*, Chapter 20. Also H. G. Lewin, *The Railway Mania and its Aftermath*. London, 1936.
2. See H. G. Lewin, *The British Railway System* (to 1844), 2nd edition, 1925.

lines had as their main object the improvement of the coal trade (e.g. the Wigan Branch railway).

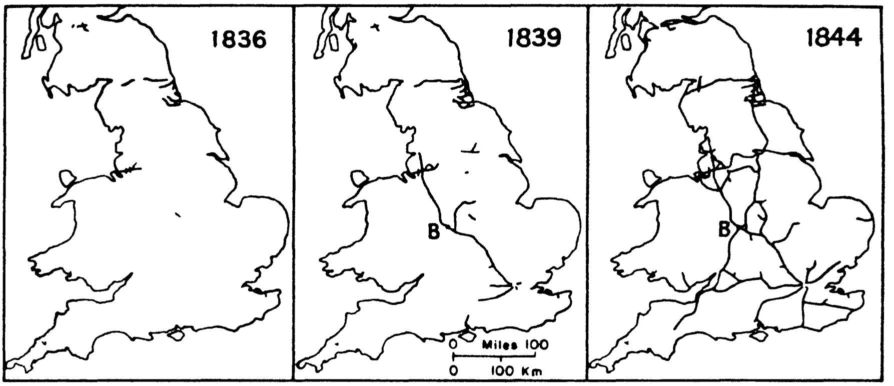



FIG. 240. The growth of the British railway network

B – Birmingham. The two curious outlying lines, Bodmin–Wadebridge (Cornwall) and Canterbury–Whitstable (Kent) are interesting. The former was constructed to carry shelly sand from the Camel estuary to the agricultural lands around Bodmin, the latter to carry coal to Canterbury owing to the silting of the river Stour

In the 1840s the nucleus of the subsequent Midland railway began to appear. This series of lines (Midland Counties, Rugby–Leicester–Derby; North Midland, Derby–Chesterfield–Leeds; Derby and Birmingham junction) had as its main object the improvement of Derbyshire coal trade —and it is interesting to note in this connection the way in which the subsequent Midland railway, with the same intention, extended long tentacles to all parts of the country, its powers extending as far as Yarmouth, York, Carlisle, Liverpool, Bristol, Bournemouth, Swansea, and Southend.

Many of the early railways, as we have seen, were primarily coal carriers; passenger transport was a subsidiary business. It soon became apparent, however, that except in the colliery districts of Northumberland and Durham, Lanarkshire, South Wales, and South Lancashire—all of which were close to navigable water—the canals still held a great advantage in cheapness of conveyance, and that the railways would derive far greater benefit from the carriage of human freight. The second great object of the railway promoters was thus to link up the existing large centres of population with each other and with London, an object which, as Fig. 240 shows, was in an advanced stage of progress before the mania years. By 1844 through communication was established between London and Folkestone, Brighton, Southampton, Exeter, Bristol, Manchester, Liverpool, Preston, Birmingham, York, Leeds, and Newcastle; and the future importance of Birmingham and Manchester as junctions was foreshadowed. No less than three trans-Pennine connections were complete. The absence of the Great Northern line from these maps is an interesting reflection of the nature of the country through which that line afterwards passed—an extensive agricultural tract where there was little possibility of large local traffic.

The bulk of the mileage, then, until the mania years of 1845–47, was dependent mainly upon passenger traffic for its revenue.[1] By this time the energy of the canal companies in trying to retain their traffic was beginning to wane, and from thenceforward goods traffic began to play an increasing part in the economy of the railways.

The subsequent history of the railway system is largely a story of development in hitherto neglected areas, and of amalgamations to form the great companies which existed before the grouping of 1921. We may profitably observe some of the geographical and economic consequences of that development. In the first place, the railways stimulated the growth of population and industries at their terminals and crossing points. Folkestone was the first railway-created port, but numerous others – e.g. Grimsby, Im-

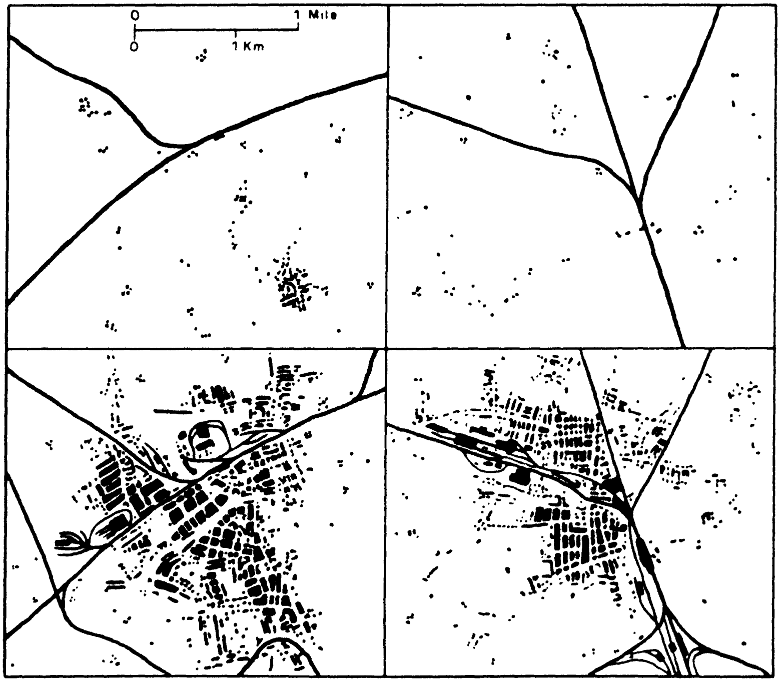



FIG. 241. Two railway-created towns – Swindon and Crewe

The two upper maps show railways and buildings in the early 1840s; the two lower maps show the same features about 1920. In each case notice the railway works. Both towns have expanded considerably since 1920 – Swindon to the east and north; Crewe to the south, southwest and northwest; but the significance of the railway as an employer of local labour has declined sharply especially since 1956, and both towns now have more balanced employment structures

1. To such an extent had the early objective of coal carrying been forgotten by some of the passenger lines that the following remark is probably representative of the more aristocratic attitude towards railways: 'Coal!' a certain Mr B. of the London and Birmingham is reported to have exclaimed when it was first suggested that his railway should carry so humble a commodity—'why, they'll be asking us to carry dung next!' (Acworth, *Railways of England*, p. 153.)

mingham, Middlesbrough, Fleetwood, Southampton, and the South Wales ports—were largely developed, if not actually created, by the forerunners of the railway companies which, before nationalisation, owner-operated them. There are many examples, too, of towns which grew up at railway junctions. The outstanding examples are Crewe and Swindon (see Fig. 241). At Crewe, before the coming of the railway, not even a village existed; and the original Swindon was a small market town on the top of an outlier of Portland stone over a mile south of the railway junction which lay in the clay vale beneath. In both these cases the growth was aided by the development of railway works. Ashford (Kent), Bletchley, and Rugby are other examples. At the crossing of rail and river the railway frequently gave a new lease of life to the decayed river ports—e.g. Lincoln, Gloucester, Chester, and Selby.

The power of the railway to attract commerce and industry was so obvious that towns which had not yet been reached pressed for new lines, lest their development should be arrested. Not only did the railways help to concentrate industry on the coalfields by transporting raw materials to the fuel supply, but, by working in the opposite direction, they allowed the survival and renewed development of old industries in localities far removed from coal as, for example, the engineering industries of the eastern counties. With the declining dominance of the coalfields as iron-producers the railways have also contributed to the scattering of industry over the countryside. In the development of the great conurbations the railways have been of prime importance. The vast daily movement of passenger and goods traffic in these thickly populated areas would be impossible without the railway. The railway web of a conurbation is well worth examining. It consists essentially of radial lines with belt connections. The most symmetrical example is Paris, but London and Manchester (Figs. 242 and 243) may be taken as equally representative. In the case of London, the radial web is particularly well developed; but it is noteworthy that the belt connections are mainly situated on the north and northwest sides—for the obvious reason that most of the traffic arrives from the Midlands and North. The function of the North London line, from Acton and Willesden to Camden, Broad Street, and the Docks; of the North and South-west Junction line, from Cricklewood (Brent sidings) *via* Neasden and Willesden to the London and South Western line, and of the West London Extension railway, linking Willesden and Old Oak Common with the great Southern Region depôts at Battersea, should be specially noted. The distribution of the goods depôts is also interesting. These are of two kinds—the terminals, where the traffic is transferred to the markets or to road vans for distribution, and the marshalling yards in the suburbs near the belt lines. Fig. 243 shows that the same general plan can be detected in the case of Manchester—although here, as might be expected, the belt lines are mainly on the south and east (i.e. on the side of the great industrial regions of the Midlands and Yorkshire). The suburban railways of London pioneered in electrification—

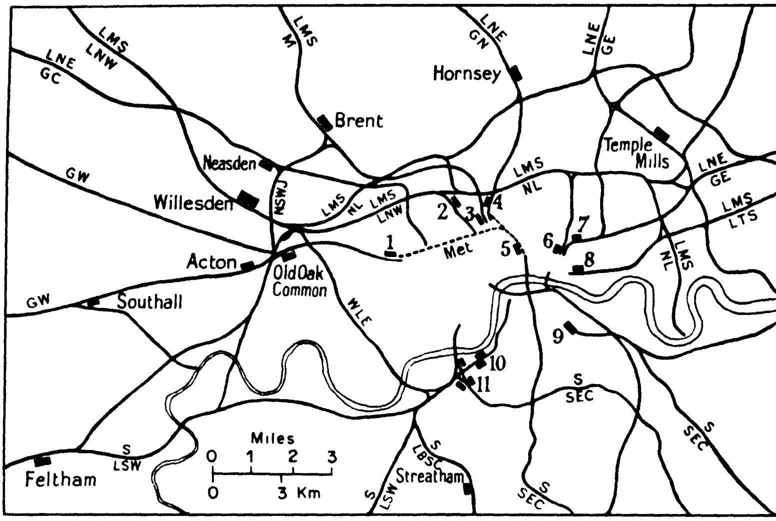



FIG. 242. The radial lines and belt connections of London, as they were before nationalisation

The principal marshalling sidings are named, terminal goods depots are numbered 1 to 11
1, Paddington; 2, Camden, 3, Somers Town, 4, Kings Cross, 5, Farringdon, 6, Broad Street, 7, Bishopsgate, 8, Fenchurch Street, 9, Bricklayers Arms, 10, Nine Elms, 11, Battersea

especially the Southern Railway—and by 1939 the Southern Railway had so extended its electrified lines on the third rail system as to have the largest suburban electrified network in the world. London led the world in electric tube railways—unified as the 'Underground' under the London Passenger Transport Board with trams (which became extinct in 1952) and buses.

The part played by the railways in the development of holiday resorts has been of immense value both to the favoured towns and to the people who are thus enabled to visit them. Many a West of England fishing village was given a new lease of life by railborne holiday traffic, and a number of the foremost resorts, for example Bournemouth, Cleethorpes, Blackpool, and Clacton, were almost non-existent before the coming of the railways.

Lastly, the railways have frequently chosen somewhat barren and thinly populated sites for the establishment of huge marshalling yards where the traffic from many areas can be re-sorted and distributed. Such are Toton, on the edge of the formerly flooded Trent lowland between Derby and Nottingham (where most of the coalfield traffic is collected before being passed on to London and the south); March, only completed in 1932, a similar concentration point for the LNER; South Crewe, at the junction of three main lines of traffic on the old LNWR (cf. Fig. 241), and Stoke Gifford, which collects Bristol and South Wales traffic on the GWR.

Two of the outstanding features of the British railway system are the perfection of its permanent way (and consequent reputation for speed) and the small size, when compared with the Continent or the United States, of its rolling-stock. The former is largely due to the way in which the lines

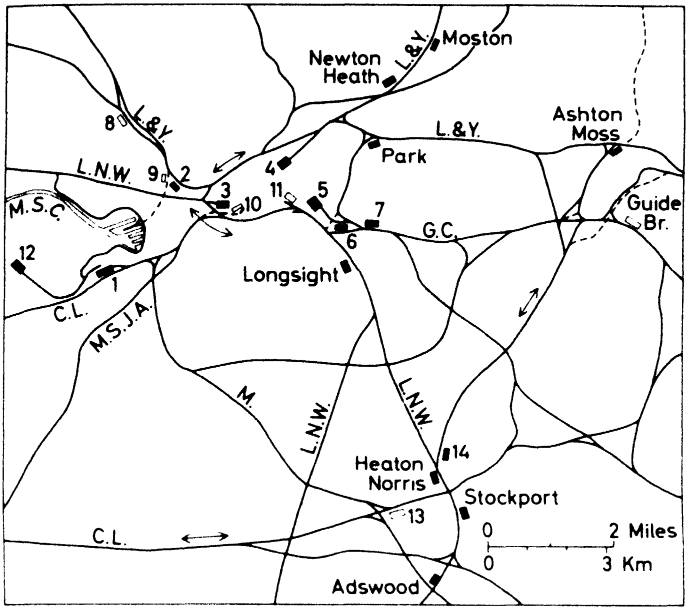



FIG. 243. The radial lines and belt connection of Manchester, 1969

Closed depots are shown in hollow symbols. Key to numbers: 1, Trafford Park, 2, Hope St., 3, Liverpool Road, 4, Oldham Road, 5, Ancoats, 6, Ashburys, 7, Ardwick, 8, Brindle Heath, 9, Windsor Bridge, 10, Deansgate, 11, London Road, 12, M.S.C. 'Containerbase', 13, Heaton Mersey, 14, Jubilee Sidings.

It is not possible to make quite the same distinction between suburban marshalling yards and terminal goods depots as it was in London. But No. 4 is the main N.C.L. depot, 3 is the 'continental' customs depot, and 1, 12 and Longsight are the freightliner terminals. Double-ended arrows show the main routes used by through traffic.

were originally built. In the first place, solidarity of construction was a policy carried to extreme degrees in order to satisfy those who feared for the safety of the trains; secondly, the early engineers were for the most part haunted by a fear that the locomotive would only run on level or nearly level lines, hence the extraordinary care taken, by the provision of deep cuttings and tunnels and lofty embankments, to ensure the gentleness of gradients.[1] Another legacy from the early days is a small loading gauge (i.e. width and height of carriages and engines allowed)—from our pioneer experience of which continental builders profited by employing a larger one—but full development under such conditions would have been difficult but for our excellent coal supplies of high calorific value.

During the First World War, the railways were taken over temporarily by the State. It may be said that experience thus gained in unified working led to the consolidation of the numerous pre-existing companies into four great groups from 1 January 1923—London, Midland and Scottish;

1. See S. H. Beaver, 'Geography from a railway train', *Geography*, **21**, 1936, 265–83.

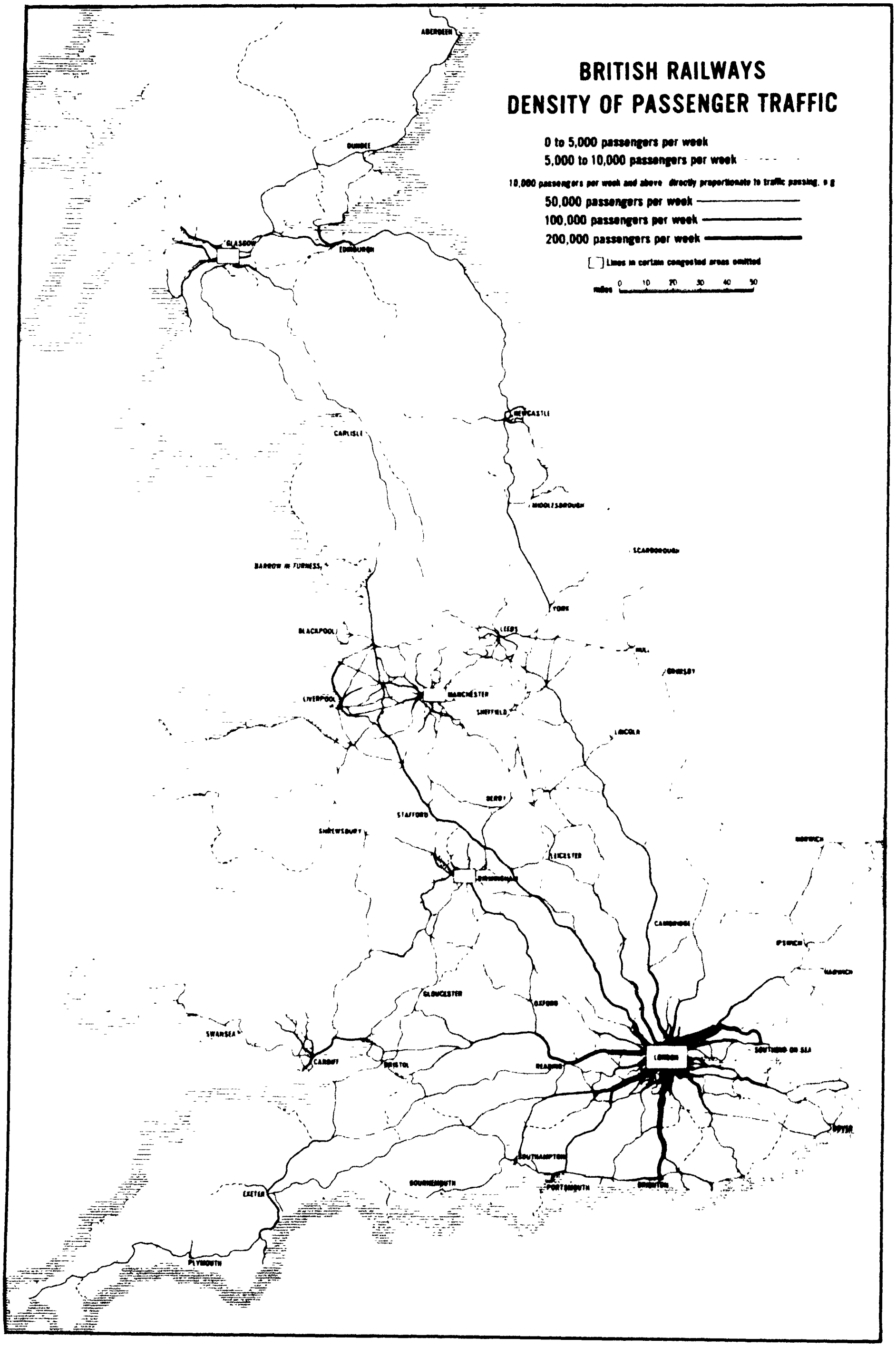



FIG. 244. The volume of passenger traffic on British railways, 1962

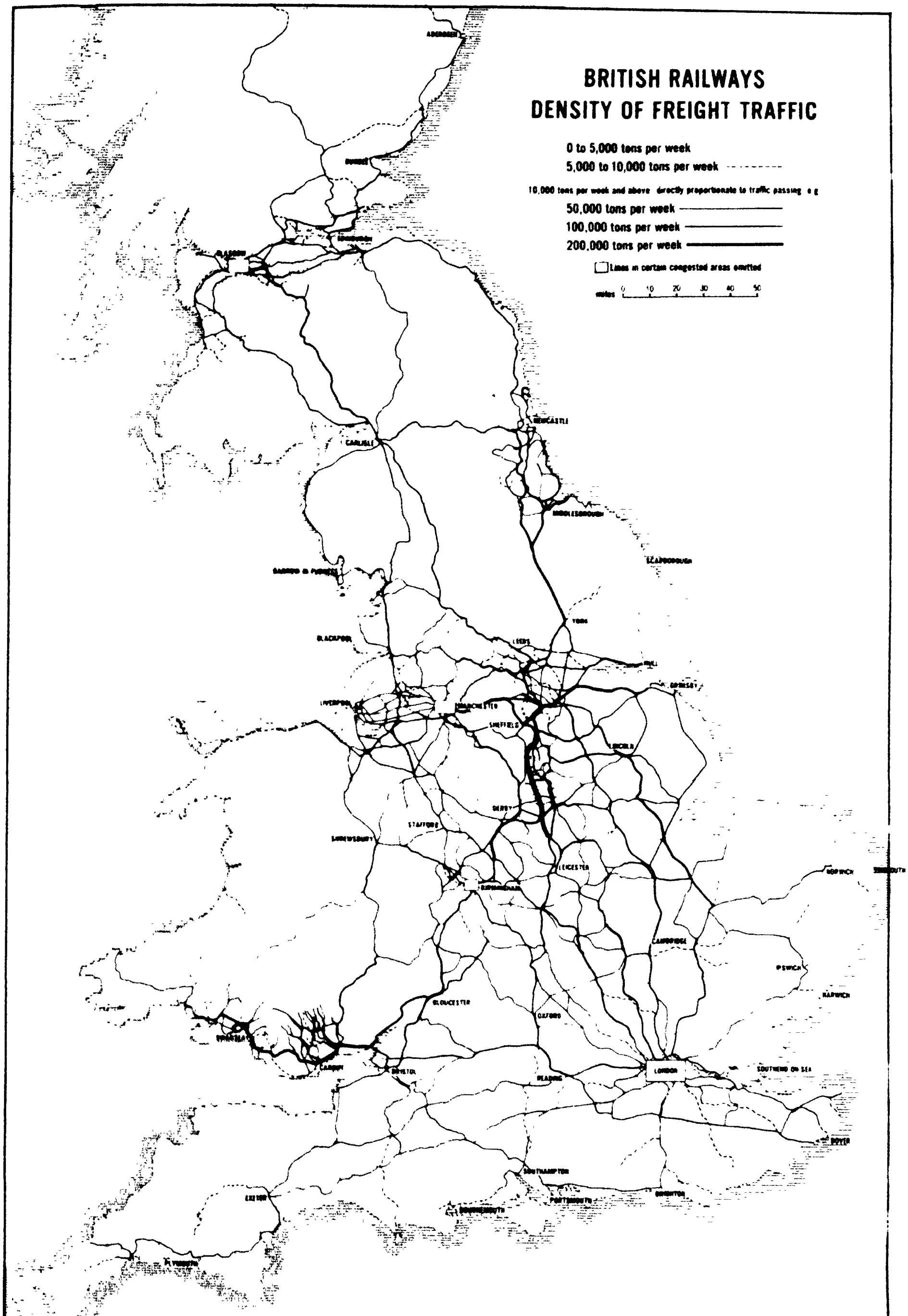



FIG. 245. The volume of freight traffic on British railways, 1962

London and North Eastern; Great Western; and Southern. Again, in the Second World War, the State took control and nationalisation as British Railways followed in 1948.

PLATE 26 The 'new look' in British Rail's freight traffic the freightliner terminal at Dudley, in the heart of the Black Country

The four railway systems which existed from 1923 to 1948 had carried out a large measure of integration within their areas by absorbing canals, steamer services, road transport services for both goods and passengers, hotels and catering services. At the same time they had preserved a considerable measure of competition. Two groups served Scotland and there was friendly rivalry between the *Royal Scot* of the LMS west coast route and the *Flying Scotsman* of the LNER east coast route. The GWR and SR were rivals in the South-west, both serving Exeter and Plymouth. London to the Midlands traffic brought the GWR and LMS into competition—as to

Birmingham. With nationalisation road services were separated from rail and the hotels-catering was also divorced: there was little element of competition left. Largely as a result of road competition and the decline of freight traffic, the nationalised railway system showed ever-increasing annual losses, despite such radical changes as main line electrification, continued electrification of suburban lines, including all the southeast coast; the substitution of diesel locomotives for steam, and the extensive use

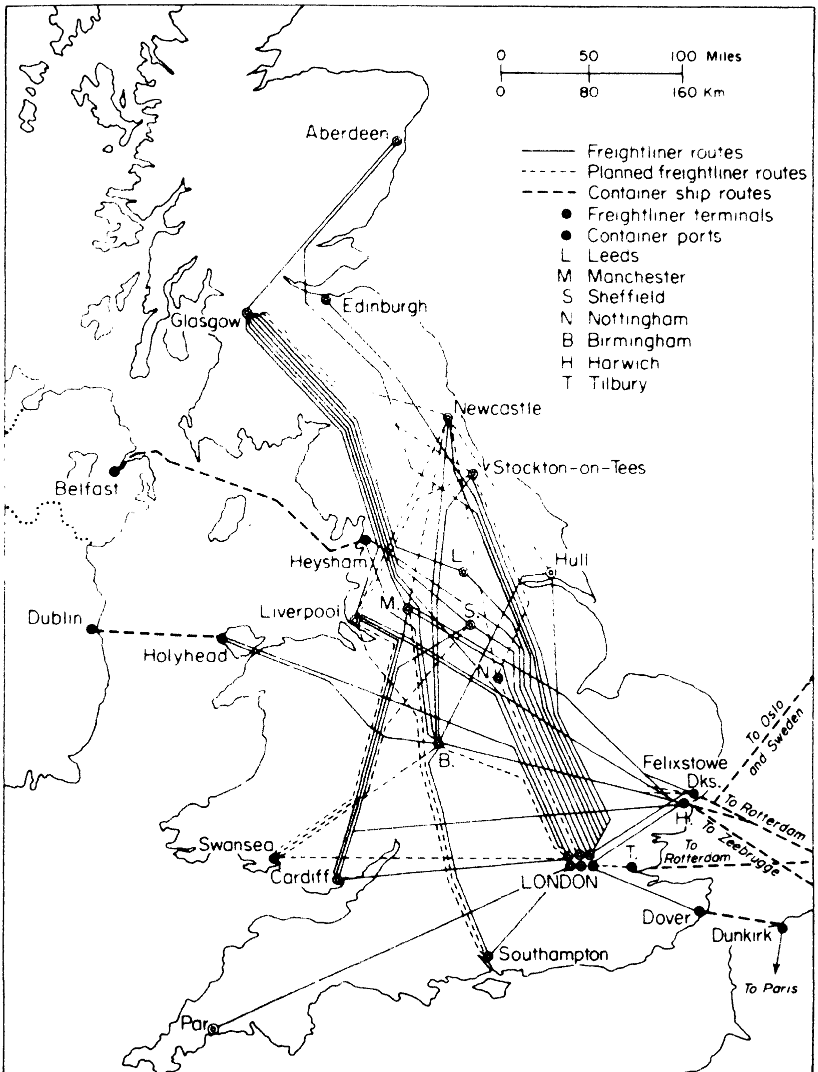



FIG. 246. Freightliner and container ship routes, 1968

(From *Geographical Digest* 1969 by permission of George Philip and Son, Ltd.)

of diesel rail cars. The position in 1962 is shown by the two official maps here reproduced, giving density of passenger and freight traffic respectively.

The desperate financial position led to the report prepared by Dr Beeching and published in April 1963. Its drastic proposals included the closing of about one third of the total railway mileage and some 4000 stations, and although the report's recommendations were not implemented in their entirety, there has been a steady reduction in passenger services. The number of stations has been reduced from 5474 in 1956 to 2888 in 1966, and the route from 30 617 kilometres (19 025 miles) to 21 067 kilometres (13 721 miles) in the same period. Freight services have been reorganised, with the introduction of the express 'Liner Trains', and the rationalisation of freight depots in many large towns has released much railway property for other uses.[1]

Electrification of the trunk lines between London, Birmingham, Crewe, Liverpool and Manchester was completed in 1967 and the last scheduled steam-hauled train ran in June 1968. The most recent railway plan envisages a basic network of some 17 700 kilometres (11 000 miles), including lines which it is hoped will eventually be commercially viable and others which will probably be supported on grounds of social benefit by some form of subsidy.

It remains in this chapter to call attention to the more recent trends in transport.

## Roads

Undoubtedly the extraordinary expansion of the road haulage of freight and the use of the private car take pride of place. There are now very few villages in the country which are not reached by a public bus service of some sort, be it only on the local market day, and the resulting traffic patterns, which are at the same time emphasising existing urban nodalities and creating new foci, have been the subject of interesting investigations by F. H. W. Green (see above p. 657). About 60 per cent of all the internal freight now travels by road and an estimated 10 per cent of passenger travel is by bus, coach or private car, and in consequence the economic position of the railways has been seriously undermined. This is of course a world-wide problem by no means confined to Britain, but in contrast with the United States and certain European countries, the reorganisation of the road system necessary to cope with this expansion of traffic has only been initiated in the last decade. A few bypasses and a few 'arterial roads' leading out of the larger cities were built during the 1920s and 1930s and after

1. See J. A. Patmore, 'The changing network of British Railways', *Geography*, **47**, 1962, 401–5; also J. H. Appleton, 'Some geographical aspects of the modernisation of British railways', *Geography*, **52**, 1967, 357–73. A further 1209 kilometres (751 miles) were closed in 1967–68; see J. H. Appleton, *Disused Railways in the Countryside of England and Wales*, a report to the Countryside Commission, HMSO, 1970.

the war, but in general the roads remained until recently much as they were in 1900 and the problems of congestion and accidents were immense.

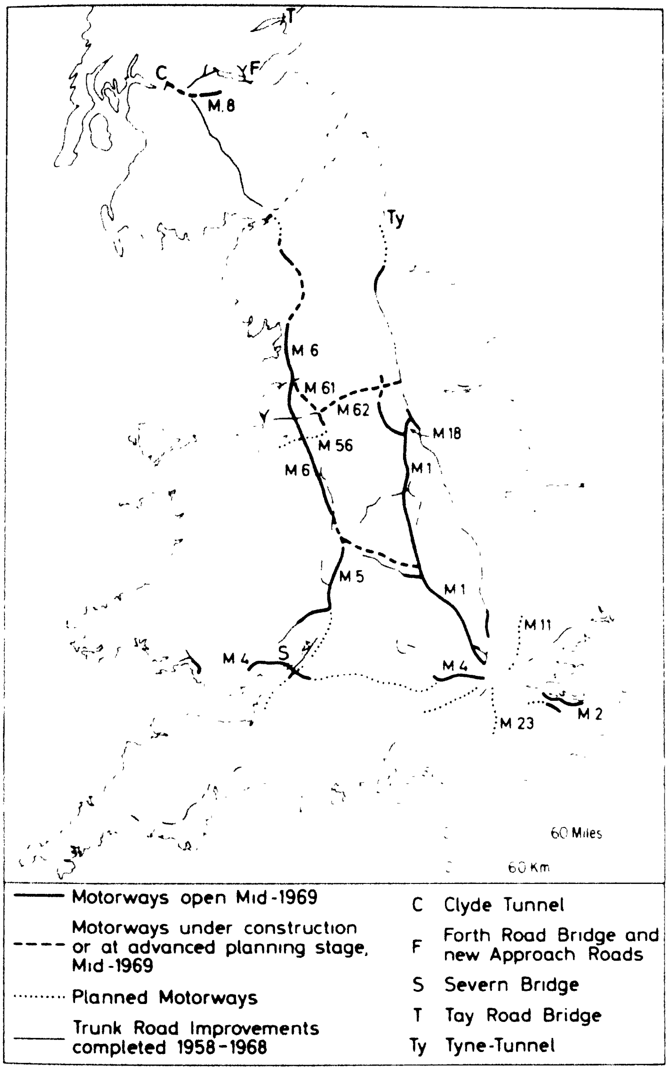



FIG. 247. Motorways in 1969

This map bears an almost uncanny resemblance to the railway map of 1844 (Fig. 240).

After the First World War the public roads of Britain were classified as 'A', which were numbered, 'B' (likewise numbered) and 'C', or unclassified roads. At a later date a small number of the chief A roads were recognised as trunk roads and their upkeep (except where they pass through large towns) became the responsibility of the central government. Other-

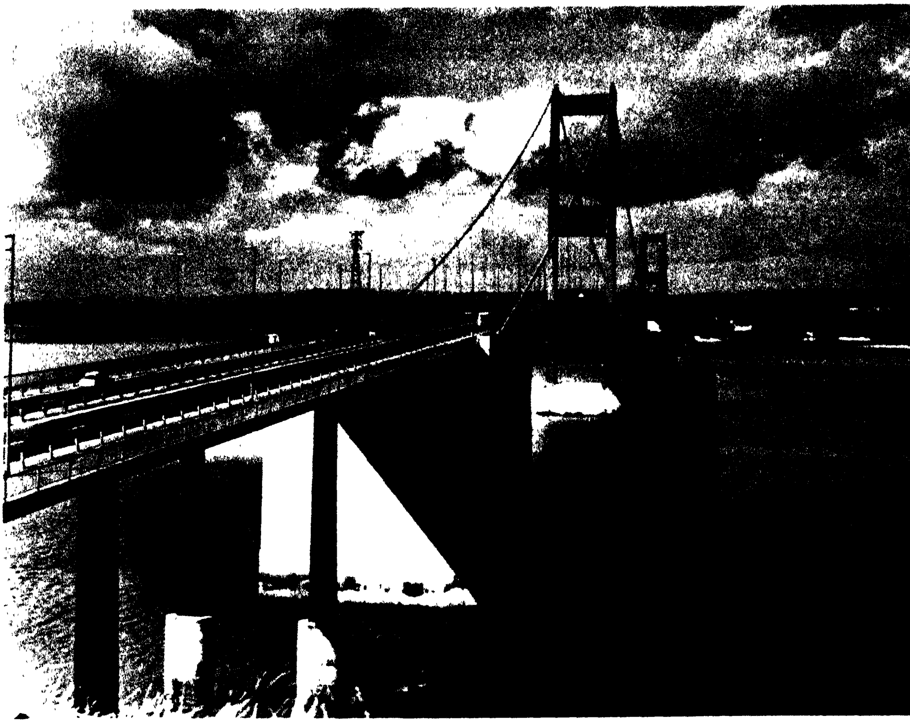


PLATE 27. The Severn Bridge
Opened in 1966, this bridge forms a vital link in the road communications between England and South Wales

wise the county is the highway authority. National road-planning initiated during and after the 1939–45 war culminated in the publication in 1948 by the Ministry of Transport of a proposed new road system of trunk and motor roads. The Special Roads Act of 1949 restricted the use of the proposed motorways to motor traffic only and in 1958 the Preston bypass was opened as the first section of the planned 1600 kilometres (1000 miles) of motorway. This total has now been increased to 2175 kilometres (1350 miles) of which about 1200 kilometres (750 miles) form the basic network of interconnected routes (M1, M4, M5 and M6) with the remaining mileage in the form of isolated sections, such as the M2 Medway Towns bypass in Kent. At the end of 1968 853 kilometres (530 miles) of motorway were open, and a further 240 kilometres (150 miles) were under construction including the important M62 trans-Pennine section linking Manchester and Leeds (Fig. 247).

This national programme for the construction of entirely new motor routes is supplemented by an ambitious plan for the improvement of trunk routes. The A1 has now been rebuilt throughout much of its length, with many bypasses of motorway standard, and the replacement of estuarine ferry links on the trunk road system is eliminating frustrating delays to

traffic. The Forth Road Bridge, just west of the railway bridge, was opened in 1964 and followed two years later by the Tay bridge and by that spanning the Severn estuary (Plates 27 and 28). In urban areas additional tunnels are being driven to alleviate congested river crossings: the second Blackwall tunnel in London and the Tyne tunnel were opened in 1967, and a second tunnel under the Mersey is in progress.

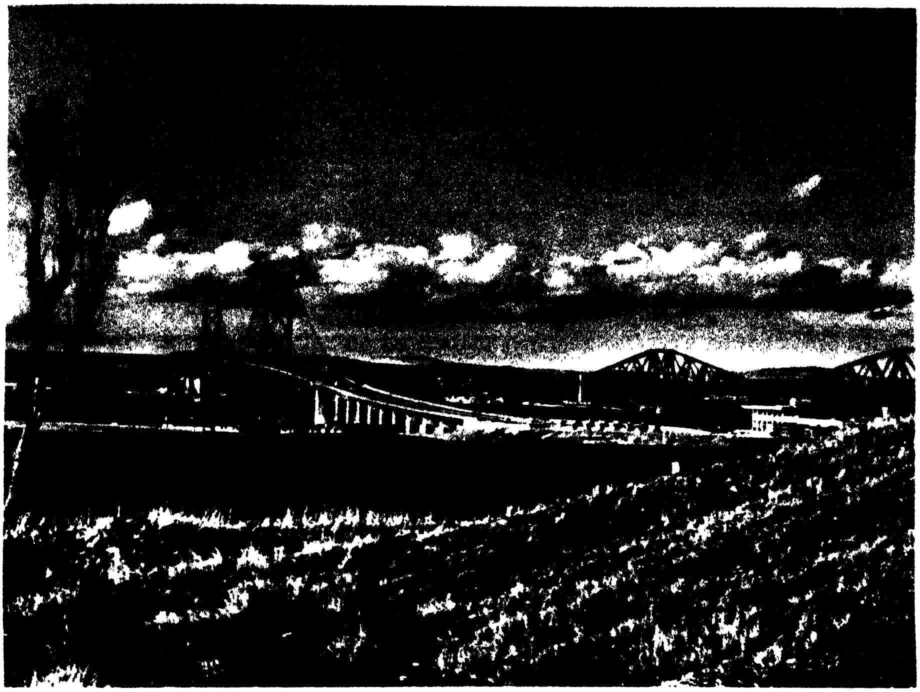


PLATE 28. The Forth bridges, rail and road

Improvements in urban transport have been designed to accommodate the ever-increasing numbers of private cars, and most large cities have now produced road plans incorporating sections of urban motorways. Such roads are highly expensive to construct as a result of land prices and the need for frequent viaducts, cuttings and even tunnels, and to date the only such roads completed are the M4 in West London, the Hendon extension of the M1, and the 'Mancunian Way' in Manchester.[1] The authorities in most of Britain's conurbations have now initiated land-use/transportation surveys involving the collecting of data on all aspects of travel and associated industrial, commercial and social activities and with the general aim of integrating transport planning with future city development as a whole.

1. The most recent and most spectacular example was opened in 1970—in the Tame valley between Walsall and West Bromwich. Here the M1, M5 and M6 meet in a series of curved viaducts that quickly became known as 'spaghetti junction'!

## Pipelines[1]

As a means of transportation the pipeline is now an integral part of the whole system—quite apart of course from its long-established use for the transference of water and gas from source to consumer. The pipeline has many advantages for the transport of materials in liquid or slurry form—it is laid underground and so is unseen, and interferes but little with surface land use, it reduces considerably the amount of tanker traffic on both road and railway, and it can ensure a constant flow of materials.

Most of the now considerable pipeline network has already been referred to in previous chapters. Crude oil pipelines are shown on Fig. 157; in addition there are petroleum products pipelines linking London Airport (Heathrow) with the oil refineries at Fawley and Isle of Grain, linking Thames-side refineries with those on Merseyside, and linking the Merseyside refineries with the ICI Severnside chemical complex. Natural gas pipelines are shown on Fig. 150; with the advent of North Sea gas this network is likely to be considerably extended. Petrochemical feedstock pipelines are referred to on p. 587; the most important link Fawley oil refinery with Severnside, and the Merseyside refineries with the chemical industries on Tees-side and at Fleetwood. Lastly an interesting pipeline carries chalk slurry from quarries in the Chiltern Hills to a cement works at Rugby, where the original basis of Lower Lias limestone has been worked out (cf. p. 365).

## Airways

Distances in Britain are too small for internal air services to displace rail to the extent that they have done in countries of great distances, such as the United States. When the time taken to reach one of the London airports from the centre of London is added to that from the provincial airport to the city centre, the margin of time saved is small over distances of under 300 kilometres (200 miles). Advertisements for the high-speed electric train services between London, the Midlands, Manchester and Liverpool emphasise the advantages of 'city centre to city centre' travel. Nevertheless, the air age has come to stay, and the increase in both passenger and freight traffic during the last two decades has been phenomenal, as the following table shows:

*Domestic air traffic*

| | 1952 | 1961 | 1967 |
|---|---|---|---|
| Passengers (thousands) | 669 | 2841 | 5314 |
| Passenger-kilometres flown (millions) | 186 | 965 | 1941 |
| Passenger-miles flown (millions) | 116 | 600 | 1206 |
| Cargo freight (thousand short tons) | 3 | 19 | 74 |

1. See R. T. Foster, 'Pipeline development in the United Kingdom', *Geography*, **54**, 1969, 204–11.

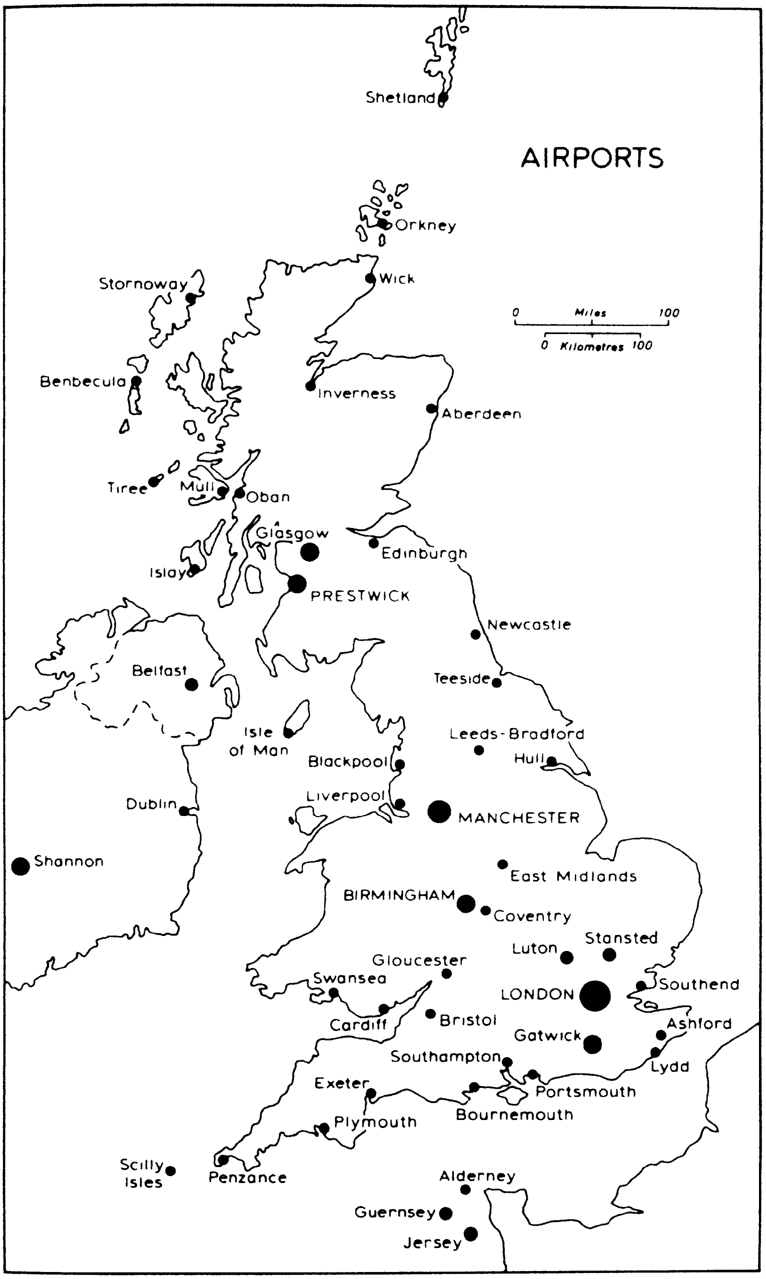



FIG. 248. Airports in 1969

Though such services as London–Glasgow and London–Manchester are well used, air transport, especially for passengers, has come into most prominence where a sea crossing is involved—notably for holiday traffic to the Channel Islands and Isle of Man and for regular traffic to Belfast and Dublin, from Penzance to the Scilly Isles and from the Scottish mainland to the Outer Hebrides, Orkney, and Shetland. Car ferries for motorists and their cars across the Channel form a special type of 'foreign' traffic with fourteen different routes from Southend, Lydd or Ferryfield (Kent), and Hurn (Hants)—two going direct as far as Switzerland. Normal international services, especially long distance, tend to be concentrated on London (Heathrow), equipped to take the largest aircraft in existence, but Manchester, Prestwick (for Glasgow) and Shannon (near Limerick) are extensively used as ports of call.

As with domestic air traffic, international air traffic has increased enormously since the Second World War, as the tables below show. Not only has the amount of travel increased, but the share of aircraft in international passenger movement is also increasing steadily at the expense of the ocean liner. In 1960, out of 13 million persons entering or leaving Britain, 5.9 millions (47 per cent) did so by air; in 1968 the total had risen to 25 million travellers, of whom 63 per cent travelled by air.

*International air traffic (UK airlines only)*

| | 1952 | 1961 | 1967 |
|---|---|---|---|
| Passengers (thousands) | 1064 | 4010 | 7004 |
| Passenger-kilometres flown (millions) | 1814 | 6326 | 12 126 |
| Passenger-miles flown (millions) | 1127 | 3931 | 7535 |
| Cargo freight (thousand short tons) | 32 | 233 | 245 |

*Foreign trade of airports, 1967* (in £m)

| AIRPORT | IMPORTS | EXPORTS | RE-EXPORTS | TOTAL |
|---|---|---|---|---|
| London | 475.5 | 431.2 | 55.0 | 961.8 |
| Manchester | 34.6 | 32.6 | 1.5 | 68.6 |
| Prestwick | 30.5 | 31.8 | 1.1 | 63.4 |
| All others | 139.9 | 79.4 | 5.6 | 229.3 |

Total trade by air, £1323.2m; by sea, £10956.6m; by land route to Eire, £83.2m.

Naturally enough, the aeroplane cannot compete with the ocean freighter, but the amount, and in particular the value, of air freight, is also rising rapidly, so that in 1967 it represented 10.7 per cent of the total value of foreign trade.

London airport, indeed, in terms of the total value of its trade, is the third 'port' in the United Kingdom after the seaports of London and Liverpool (cf. table on p. 719). Its imports, unlike those of almost all the seaports, include almost nothing in the foodstuffs and raw materials categories, and are mainly made up of valuable machinery (including aircraft parts) and manufactured goods; the same classes of commodity make up the bulk of the export traffic, including again aircraft engines and parts and office machinery; the re-exports include quantities of furskins, and more machinery.

British airports have undergone a rapid evolution, parallel to the aircraft they serve. Before the Second World War London was served by Croydon on a plateau surface on the chalk of the North Downs and by Northolt to the northwest; it was during the war that a search was made for the much larger area which would be needed. The only site seemed to be an extensive area a dozen miles west of the heart of London occupied by market gardeners producing intensively from one of the finest stretches of brick-earth soils in

PLATE 29. London Airport, Heathrow

the country. It was one of the first head-on collisions between urban needs and the newly declared policy of conserving good agricultural land. It would be wrong to say agriculture lost because all land planning is in the national interest, and above all Britain's capital had to have a first-class airport. It is interesting to note that there is no rail access: it is solely by road. Croydon in due course was abandoned, Northolt was discontinued as a civil airport, but congestion at Heathrow led to the opening of Gatwick some thirty miles south on the main electrified line to Brighton in 1958. Blackbushe and Stansted (Essex) act as emergency subsidiaries. The trouble in Britain, as all over the world, is to find the necessary space—with runways two miles and more in length for giant jets—sufficiently near the urban centres they are to serve.

A large proportion of Britain's internal air services are run by BEA (British European Airways) which, as its name implies, links Britain with most European countries. Britain's other state-owned organization is BOAC (British Overseas Airways Corporation) serving extra-European destinations. The bulk of long-distance traffic is handled by London (Heathrow), Manchester (Ringway) and Prestwick, together with Shannon (Irish Republic).

# 28
# The seaports of Great Britain

The following six tables present statistically some aspects of the fortunes of British ports during the last half-century. Tables 1, 3, 4 and 5 are expressed in percentages and so give a measure of the relative importance of the various ports at different periods. In reading Table 2, however, which is expressed in terms of value, the great change in the value of money must be borne in mind; because London's trade is now worth eight times as much as in 1913 this does not mean that the actual traffic has increased eightfold in volume. The figures in Table 6, giving the tonnage of vessels cleared from the ports, have of course been considerably affected by changes in the character of shipping. Southampton's figures for many years were swelled by the 80 000 tons a week represented by the transatlantic sailings of the *Queens*, but quite fundamental changes are now being wrought by the 'supertankers' which have, for example, converted Milford Haven from a small fishing creek into the fourth freight port in the United Kingdom.

Table 1 illustrates two facts of outstanding importance. The first is the concentration of the huge trade of the United Kingdom in a few major ports. Thus the first six on the list handle nearly three-quarters of the total traffic. Even more remarkable are the figures for the first two—London and Liverpool between them handling over one-half of the total foreign sea-borne trade of the United Kingdom. The second point of importance is that this concentration of trade on the major ports has been a feature of the growth of British trade for a long time and, what is perhaps still more significant, it is still maintained, despite the temporary eclipse of London during the Second World War. The table also reveals, however, the decline of the coal exporting ports of Cardiff and the Tyne, and also of the Clyde and of Liverpool; and the footnote indicates that, despite the decline of many of the minor ports round the coasts, certain ports have increased in importance, notably the East Anglian ports of Harwich and Felixstowe, with their mainly short-sea-route European trade, whilst new ports concerned with the oil trade, such as Milford Haven, have come into the picture.

Table 2 tells something of the same story in a different way, using figures of the value of trade. Whereas the total United Kingdom trade has in-

creased in value by just over 8 times between 1913 and 1967, and that of London in almost exactly the same proportion, the value of Liverpool's trade has increased by only 5 times, that of the Tyne by only $4\frac{1}{2}$ times, that of Glasgow by $5\frac{1}{2}$ times, and that of Cardiff by only $2\frac{1}{2}$ times; whilst that of Harwich has increased by $9\frac{1}{2}$ times, and that of the 'other ports' by no less than fourteen times.

Tables 3 and 4, based on the value of trade, show the fluctuations in the relative importance of the ports in terms of exports and imports. London has clearly maintained its overall position with an increasing share of exports balancing a declining share of imports, while Liverpool has declined on both counts. The improvement in the relative positions of Harwich, Felixstowe and Dover reflects our increasing trade with the near Continent; whilst Cardiff's virtual fade-out from the exports list results from the extinction of its coal trade, and Milford Haven, Swansea and Grangemouth have all risen in the import list as a result of petroleum imports.

The entrepôt or re-export trade is shown in Table 5. In terms of the value of such trade, three facts stand out clearly: first the continuing dominance of London, secondly the decline of Liverpool and thirdly the importance of re-exports via the short sea routes to the Continent. If one takes re-export *tonnage* figures, a rather different picture emerges, for considerable recent changes have been brought about by the oil industry, which imports oil in large tankers and re-exports it in smaller tankers to refineries in other countries. Thus, in terms of tonnage, Milford Haven is now second to London as a re-exporter, with 27 per cent of the total as against London's 46 per cent. Liverpool is third with 7 per cent (partly made up of oil) and Swansea (another oil port) fourth with 3.5 per cent. Excluding oil, however, London is now more dominant than ever before in the entrepôt trade, with about two-thirds of the total tonnage.

Table 6, which deserves careful study and comparison with the previous tables, brings out a number of interesting points: (*a*) the importance of coastwise traffic, spread over a wide range of ports; (*b*) the 'passenger' ports—transatlantic like Southampton and short-sea-route like Dover and Holyhead (where the numerous daily services of cross-channel ships cause a large tonnage total to mount up), together with the inter-island ferry ports such as the Isle of Wight, Portsmouth and Belfast; (*c*) the rise of the 'other ports' in foreign traffic—including the purely oil ports such as Milford Haven and the recently expanded 'container' port of Felixstowe; (*d*) the general large increases in ocean-going tonnage since 1952 at several ports, such as London and Southampton, which now have substantial oil refineries and are visited at frequent intervals by giant tankers.

*1. Trade of the leading ports expressed as a percentage of value of the total trade*

| PORT | 1913 | 1926–30 | 1935 | 1948 | 1960 | 1967 |
|---|---|---|---|---|---|---|
| London | 29.3 | 34.5 | 37.7 | 31.8 | 33.9 | 33.3 |
| Liverpool | 26.4 | 23.3 | 22.0 | 27.3 | 21.4 | 18.0 |
| Hull | 6.3 | 5.3 | 6.0 | 5.3 | 5.4 | 6.7 |
| Manchester | 4.0 | 4.7 | 4.3 | 5.6 | 5.0 | 4.5 |
| Southampton | 3.8 | 4.5 | 4.4 | 3.0 | 3.9 | 4.2 |
| Glasgow | 3.9 | 4.0 | 3.8 | 4.4 | 3.6 | 3.3 |
| Harwich | 2.4 | 2.5 | 2.0 | 0.7 | 1.8 | 3.2 |
| Tyne ports | 1.7 | 1.9 | 1.9 | 1.5 | 1.4 | 1.1 |
| Dover and Folkestone | 2.5 | 1.8 | 1.2 | 1.1 | 1.7 | 2.3 |
| Bristol | 1.5 | 1.8 | 2.0 | 2.9 | 2.6 | 2.6 |
| Grimsby | 2.7 | 1.7 | 1.4 | 1.0 | 1.0 | 1.1 |
| Goole | 1.3 | 1.3 | 1.1 | 0.8 | 0.9 | 1.0 |
| Leith | 1.6 | 1.3 | 1.1 | 0.8 | 0.7 | 0.9 |
| Cardiff | 1.7 | 1.1 | 1.1 | 0.8 | 0.6 | 0.6 |
| Newhaven | 1.5 | 0.7 | 0.6 | 0.4 | 0.4 | |
| Other ports, Gt. Britain | 8.0 | 8.3 | 8.3 | 11.3 | 14.8 | 16.2 |
| Northern Ireland | 1.4 | 1.3 | 1.3 | 1.3 | 0.9 | 1.0 |

The first six (London, Liverpool, Hull, Manchester, Southampton, and Glasgow) 73.7 per cent of the total in 1913, 76.3 per cent in 1926–30, 77.4 per cent in 1931; 80.2 per cent in 1935, 77.4 per cent in 1948, 73.2 per cent in 1960, 69.7 per cent in 1967. In 1967 among 'other ports' Felixstowe (2.4) and Milford Haven (1.3) have risen considerably in importance.

*2. The leading British ports arranged according to the value of their trade* (in £m)

| PORT | 1913 | 1926–30 AVERAGE | 1935 | 1948 | 1960 | 1967 |
|---|---|---|---|---|---|---|
| London | 411.8 | 681.9 | 466.7 | 1 179.9 | 2 793.1 | 3 406.5 |
| *Imports* | *253.9* | *470.4* | *321.4* | *673.2* | *1 523.4* | *1 773.8* |
| *Exports* | *99.1* | *148.1* | *112.2* | *483.2* | *1 212.4* | *1 580.4* |
| *Re-exports* | *58.8* | *67.5* | *33.1* | *23.5* | *57.3* | *52.2* |
| Liverpool | 370.8 | 460.6 | 271.8 | 1 091.6 | 1 759.4 | 1 817.4 |
| *Imports* | *175.5* | *220.4* | *139.8* | *545.8* | *809.9* | *893.3* |
| *Exports* | *170.1* | *222.8* | *125.5* | *533.4* | *923.6* | *910.2* |
| *Re-exports* | *25.2* | *17.4* | *6.5* | *12.4* | *25.9* | *13.9* |
| Hull | 84.6 | 104.1 | 74.4 | 198.7 | 444.4 | 677.3 |
| *Imports* | *49.8* | *71.4* | *48.5* | *127.0* | *259.0* | *353.6* |
| *Exports* | *29.2* | *31.2* | *24.8* | *64.6* | *182.3* | *319.4* |
| *Re-exports* | *5.6* | *1.5* | *1.1* | *5.1* | *3.1* | *4.3* |
| Manchester | 56.3 | 93.1 | 52.9 | 208.7 | 414.0 | 449.9 |
| *Imports* | *35.3* | *63.0* | *39.8* | *138.6* | *285.2* | *301.1* |
| *Exports* | *20.6* | *29.4* | *12.8* | *69.4* | *127.9* | *147.7* |
| *Re-exports* | *0.4* | *0.7* | *0.4* | *0.7* | *0.9* | *1.1* |

| PORT | 1913 | 1926–30 AVERAGE | 1935 | 1948 | 1960 | 1967 |
|---|---|---|---|---|---|---|
| Southampton | 53.6 | 88.9 | 54.9 | 113.3 | 320.3 | 429.6 |
| *Imports* | *25.5* | *40.6* | *26.1* | *53.5* | *191.8* | *246.5* |
| *Exports* | *20.7* | *37.2* | *23.5* | *57.4* | *123.5* | *177.7* |
| *Re-exports* | *7.4* | *11.1* | *5.3* | *2.4* | *5.0* | *5.3* |
| Glasgow | 54.8 | 79.5 | 46.7 | 162.5 | 293.8 | 312.1 |
| *Imports* | *18.5* | *29.9* | *20.1* | *73.0* | *137.0* | *152.3* |
| *Exports* | *35.9* | *48.6* | *26.1* | *89.2* | *154.9* | *158.7* |
| *Re-exports* | *0.4* | *1.0* | *0.5* | *0.3* | *1.9* | *1.1* |
| Harwich | 34.3 | 48.4 | 25.0 | 25.8 | 147.2 | 323.1 |
| *Imports* | *25.6* | *41.8* | *20.1* | *14.3* | *84.1* | *175.3* |
| *Exports* | *6.0* | *4.9* | *3.7* | *10.2* | *60.2* | *141.4* |
| *Re-exports* | *2.7* | *1.7* | *1.3* | *1.3* | *2.9* | *6.5* |
| Tyne ports | 24.6 | 36.9 | 23.1 | 55.6 | 111.8 | 110.3 |
| *Imports* | *11.4* | *20.9* | *11.6* | *29.2* | *63.9* | *63.6* |
| *Exports* | *13.2* | *15.8* | *11.3* | *26.1* | *47.6* | *45.7* |
| *Re-exports* | *0.0* | *0.2* | *0.1* | *0.3* | *0.3* | *1.0* |
| Dover and Folkestone | 35.2 | 35.3 | 15.6 | 41.2 | 140.4 | 241.0 |
| *Imports* | *24.4* | *22.7* | *8.7* | *23.2* | *66.2* | *120.8* |
| *Exports* | *6.7* | *6.9* | *4.4* | *14.4* | *67.7* | *169.2* |
| *Re-exports* | *4.1* | *5.7* | *2.5* | *3.6* | *6.5* | *11.0* |
| Bristol | 22.1 | 35.0 | 24.6 | 108.4 | 212.9 | 259.0 |
| *Imports* | *18.0* | *30.9* | *23.4* | *100.1* | *179.8* | *216.8* |
| *Exports* | *4.0* | *3.7* | *0.9* | *7.8* | *32.1* | *47.0* |
| *Re-exports* | *0.1* | *0.4* | *0.3* | *0.5* | *1.0* | *1.1* |
| Grimsby | 37.9 | 34.0 | 17.4 | 33.6 | 85.9 | 111.6 |
| *Imports* | *15.9* | *21.6* | *12.3* | *20.5* | *69.7* | *83.5* |
| *Exports* | *21.9* | *12.0* | *5.1* | *11.3* | *16.0* | *27.4* |
| *Re-exports* | *0.1* | *0.4* | *0.05* | *1.8* | *0.2* | *0.7* |
| Goole | 18.8 | 25.8 | 13.1 | 28.1 | 73.5 | 106.2 |
| *Imports* | *8.4* | *12.2* | *5.0* | *10.0* | *36.2* | *55.5* |
| *Exports* | *10.3* | *13.5* | *8.0* | *17.6* | *36.7* | *49.8* |
| *Re-exports* | *0.1* | *0.1* | *0.1* | *1.5* | *0.6* | *0.8* |
| Leith | 23.0 | 24.6 | 13.3 | 28.6 | 61.3 | 87.8 |
| *Imports* | *15.8* | *19.0* | *10.1* | *22.4* | *44.7* | *55.2* |
| *Exports* | *6.9* | *5.4* | *3.1* | *6.2* | *16.5* | *32.1* |
| *Re-exports* | *0.3* | *0.2* | *0.1* | — | *0.1* | *0.5* |
| Cardiff | 23.9 | 22.5 | 13.1 | 29.0 | 48.7 | 61.1 |
| *Imports* | *6.7* | *9.6* | *4.8* | *17.9* | *37.5* | *43.8* |
| *Exports* | *17.2* | *12.9* | *8.3* | *10.2* | *10.5* | *17.2* |
| *Re-exports* | *0.0* | *0.0* | *0.0* | *0.9* | *0.7* | *0.1* |

| PORT | 1913 | 1926–30 AVERAGE | 1935 | 1948 | 1960 | 1967 |
|---|---|---|---|---|---|---|
| Newhaven | 21.0 | 13.5 | 7.0 | 14.0 | 36.7 | 34.5 |
| *Imports* | *13.5* | *8.8* | *3.2* | *10.2* | *20.2* | *18.0* |
| *Exports* | *5.0* | *3.5* | *2.2* | *3.3* | *15.7* | *15.6* |
| *Re-exports* | *2.5* | *1.2* | *1.6* | *0.5* | *0.8* | *1.0* |
| Other ports Great Britain | 111.6 | 164.0 | 101.0 | 357.1 | 1 218.7 | 1 532.5 |
| *Imports* | *53.3* | *86.2* | *49.3* | *181.4* | *668.5* | *984.9* |
| *Exports* | *57.8* | *74.8* | *49.9* | *166.1* | *517.2* | *547.6* |
| *Re-exports* | *0.5* | *3.0* | *1.7* | *9.6* | *33.0* | *83.7* |
| Ports of Northern Ireland | 19.5 | 26.4 | 16.6 | 48.4 | 74.5 | 109.3 |
| *Imports* | *17.3* | *18.7* | *11.8* | *36.7* | *63.6* | *91.4* |
| *Exports* | *0.7* | *6.6* | *4.1* | *11.4* | *10.0* | *17.9* |
| *Re-exports* | *1.4* | *1.1* | *0.7* | *0.3* | *0.9* | *0.5* |
| United Kingdom Total | 1 403.6 | 1 974.2 | 1 237.2 | 3 724.5 | 8 236.6 | 11 462.9 |
| *Imports* | *768.7* | *1 184.0* | *756.0* | *2 078.0* | *4 540.7* | *6 434.1* |
| *Exports* | *525.3* | *677.2* | *425.8* | *1 581.8* | *3 554.8* | *5 028.8* |
| *Re-exports* | *109.6* | *113.1* | *55.3* | *64.7* | *141.2* | *119.6* |

In 1967 among 'other ports' Felixstowe reached a total trade of £239m, Milford Haven £135m, and Swansea £108m

*3. Export trade of the leading ports expressed as a percentage of the total seaborne export trade*

| PORT | 1913 | 1926–30 | 1935 | 1948 | 1960 | 1967 |
|---|---|---|---|---|---|---|
| London | 18.9 | 21.9 | 26.2 | 30.4 | 34.1 | 36.2 |
| Liverpool | 32.4 | 32.9 | 29.4 | 33.6 | 26.0 | 20.9 |
| Hull | 5.6 | 4.6 | 5.8 | 4.1 | 5.1 | 7.3 |
| Manchester | 4.0 | 4.3 | 3.0 | 4.4 | 3.6 | 3.4 |
| Southampton | 4.0 | 5.5 | 5.5 | 3.6 | 3.5 | 4.0 |
| Glasgow | 6.9 | 7.2 | 6.1 | 5.6 | 4.4 | 3.6 |
| Harwich | 1.1 | 0.7 | 0.9 | 0.6 | 1.7 | 3.2 |
| Tyne ports | 2.5 | 2.5 | 2.6 | 1.6 | 1.3 | 0.8 |
| Dover and Folkestone | 1.3 | 1.0 | 1.1 | 0.9 | 1.9 | 2.5 |
| Bristol | 0.8 | 0.5 | 0.2 | 0.5 | 0.9 | 1.1 |
| Grimsby | 4.2 | 1.8 | 1.2 | 0.7 | 0.5 | 0.6 |
| Goole | 2.0 | 2.0 | 1.9 | 1.1 | 1.0 | 1.1 |
| Leith | 1.3 | 0.8 | 0.8 | 0.4 | 0.5 | 0.7 |
| Cardiff | 3.3 | 1.9 | 2.0 | 0.6 | 0.3 | 0.4 |
| Newhaven | 1.0 | 0.5 | 0.5 | 0.2 | 0.4 | 0.3 |
| Other ports. Great Britain | — | — | — | — | 14.6 | 12.6 |
| Northern Ireland | — | — | — | — | 0.3 | 0.3 |

In 1967 the 'other ports' included Felixstowe (2.4), Grangemouth (2.0), Tees and Hartlepool (1.6) and Swansea (1.1).

*4. Import trade of the leading ports expressed as a percentage of the total seaborne import trade*

| PORT | 1913 | 1926–30 | 1935 | 1948 | 1960 | 1967 |
|---|---|---|---|---|---|---|
| London | 33.3 | 39.7 | 42.5 | 32.5 | 33.5 | 31.1 |
| Liverpool | 22.8 | 18.6 | 18.5 | 26.4 | 17.8 | 15.4 |
| Hull | 6.5 | 6.0 | 6.4 | 5.1 | 5.7 | 6.2 |
| Manchester | 4.6 | 5.3 | 5.3 | 5.2 | 6.3 | 5.3 |
| Southampton | 3.3 | 3.4 | 3.5 | 2.6 | 4.2 | 4.3 |
| Glasgow | 2.4 | 2.5 | 2.7 | 3.5 | 3.0 | 2.9 |
| Harwich | 3.3 | 3.5 | 2.6 | 0.5 | 1.9 | 3.0 |
| Tyne ports | 1.4 | 1.8 | 1.5 | 1.4 | 1.4 | 1.3 |
| Dover and Folkestone | 3.2 | 1.1 | 1.2 | 1.1 | 1.5 | 2.1 |
| Bristol | 2.3 | 2.6 | 3.1 | 4.8 | 4.0 | 3.7 |
| Grimsby | 2.1 | 1.8 | 1.6 | 1.0 | 1.5 | 1.5 |
| Goole | 1.1 | 1.0 | 0.6 | 0.4 | 0.8 | 1.0 |
| Leith | 2.1 | 1.6 | 1.3 | 1.1 | 1.0 | 1.0 |
| Cardiff | 0.9 | 0.8 | 0.7 | 0.9 | 0.8 | 0.8 |
| Newhaven | — | — | — | 0.4 | 0.4 | 0.3 |
| Other ports. Great Britain | — | | — | | 14.8 | 17.3 |
| Northern Ireland | | — | — | | 1.4 | 1.6 |

In 1967 'other ports' included Felixstowe (2.4), Milford Haven (2.1), Tees and Hartlepool (1.3), Swansea (1.0) and Grangemouth (0.9).

*5. Entrepôt or re-export trade of the leading ports expressed as a percentage of the total seaborne entrepôt trade* (by value)

| PORT | 1913 | 1926–30 | 1935 | 1948 | 1960 | 1967 |
|---|---|---|---|---|---|---|
| London | 53.7 | 59.7 | 59.9 | 36.3 | 40.6 | 43.7 |
| Liverpool | 23.0 | 15.4 | 11.8 | 19.1 | 18.3 | 11.7 |
| Hull | 5.1 | 1.3 | 2.0 | 8.0 | 2.2 | 3.7 |
| Manchester | 0.4 | 0.6 | 0.7 | 1.0 | 0.6 | 1.0 |
| Southampton | 6.7 | 9.8 | 9.6 | 3.7 | 3.5 | 4.5 |
| Glasgow | 0.4 | 0.9 | 0.9 | 0.5 | 1.3 | 1.0 |
| Harwich | 2.5 | 1.5 | 2.3 | 2.0 | 2.1 | 5.4 |
| Tyne ports | 0.0 | 0.2 | 0.2 | 0.5 | 0.2 | 1.0 |
| Dover and Folkestone | 3.7 | 5.0 | 4.5 | 5.8 | 4.6 | 0.2 |
| Bristol | 0.1 | 0.4 | 0.5 | 0.8 | 0.7 | 1.0 |
| Grimsby | 0.1 | 0.4 | 0.1 | 2.7 | 0.1 | 0.6 |
| Goole | 0.1 | 0.1 | 0.1 | 2.3 | 0.4 | 0.7 |
| Leith | 0.3 | 0.2 | 0.2 | — | 0.1 | 0.5 |
| Cardiff | 0.0 | 0.0 | 0.0 | 1.4 | 0.5 | 0.1 |
| Newhaven | 2.3 | 1.1 | 2.8 | 0.8 | 0.6 | 1.0 |
| Other ports. Great Britain | — | — | — | — | 23.3 | 14.4 |
| Northern Ireland | — | — | — | — | 0.6 | 0.5 |

In 1967, *seaborne* entrepôt trade represented 65 per cent of the total; 34 per cent was carried by air and 1 per cent across the Irish land boundary (cf. p. 718).

*6. The leading British ports, showing net tonnage of vessels cleared* (millions of tons)

| PORT | 1913 | | 1926–30 | | 1952 | | 1967 | |
|---|---|---|---|---|---|---|---|---|
| | FOREIGN | COASTAL | FOREIGN | COASTAL | FOREIGN | COASTAL | FOREIGN | COASTAL |
| London | 11.4 | 8.6 | 19.4 | 7.9 | 18.5 | 11.1 | 34.0 | 9.4 |
| Liverpool | 11.2 | 4.2 | 13.0 | 3.5 | 12.7 | 3.8 | 16.2 | 4.2 |
| Hull | 4.4 | 1.4 | 4.4 | 1.3 | 4.3 | 1.6 | 5.6 | 1.6 |
| Manchester | 1.5 | 1.2 | 3.0 | 1.0 | 3.4 | | 5.5 | 1.7 |
| Southampton | 6.6 | 1.6 | 10.4 | 1.5 | 13.8 | 4.1 | 20.7 | 6.3 |
| Glasgow | 4.3 | 2.0 | 4.8 | 1.5 | 4.9 | 1.8 | 6.0 | 1.6 |
| Harwich | 0.9 | 0.3 | 2.3 | 0.1 | 3.2 | | 6.7 | |
| Tyne ports | 8.5 | 3.4 | 7.4 | 2.2 | 3.7 | 4.4 | 3.9 | 3.0 |
| Dover and Folkestone | 3.2 | 0.3 | 2.8 | 0.2 | 4.5 | — | 12.2 | — |
| Bristol | 1.1 | 1.6 | 2.0 | 1.3 | 2.3 | 2.1 | 3.6 | 2.0 |
| Grimsby | 2.8 | 0.3 | 2.0 | 0.3 | 1.5 | | 4.0 | 1.6 |
| Goole | 0.8 | 0.7 | 0.7 | 0.4 | | | | |
| Leith | 1.5 | 0.8 | 1.5 | 0.7 | 0.6 | 0.4 | 0.8 | — |
| Cardiff | 10.4 | 2.2 | 7.0 | 1.2 | 2.2 | 1.8 | 1.7 | 1.0 |
| Newhaven | 0.5 | 0.2 | 0.6 | 0.1 | 0.5 | — | 0.9 | |
| Swansea | 2.8 | 0.6 | 3.2 | 0.6 | 4.3 | 1.5 | 2.3 | 1.5 |
| Blyth | 2.2 | 0.3 | 1.3 | 0.9 | 0.5 | 2.1 | | 1.2 |
| Plymouth | 3.8 | 0.9 | 6.3 | 0.5 | 1.7 | — | 0.5 | — |
| Middlesbrough | 2.1 | 1.3 | 2.4 | 0.8 | 2.9 | 0.7 | 4.6 | 1.0 |
| Holyhead and Beaumaris | 0.0 | 1.5 | 1.4 | 0.7 | 1.4 | | 2.0 | |
| Cowes and Isle of Wight | 0.0 | 1.9 | 2.0 | 2.1 | | 4.2 | | 4.6 |
| Portsmouth | 0.1 | 1.6 | 0.2 | 2.0 | | 2.8 | | 3.2 |
| Sunderland | 2.0 | 1.5 | 1.4 | 1.5 | | 2.0 | | 1.4 |
| Belfast | 0.3 | 3.1 | 2.5 | 2.9 | 0.7 | 5.2 | 2.1 | 7.1 |
| Newport, Mon | | | | | 1.7 | 0.5 | 2.0 | 0.4 |
| Lancaster | | | | | 0.7 | 1.2 | 0.3 | 1.4 |
| Falmouth | | | | | 1.7 | — | 1.5 | 0.5 |
| Milford Haven | | | | | | — | 8.5 | 3.8 |
| Other ports | | | | — | 7.9 | 24.5 | 24.6 | 22.7 |

The study of the development of British ports affords many interesting examples of the interrelation of geographic and economic factors. In the first place it is true to say that the site of every British port was determined originally by local geographical conditions. The first requirement was the provision of a safe harbourage. In the second place the situation of that safe harbourage or anchorage relative to important parts of the country and the ease of communication therewith played a leading part. Perhaps the first great test of the suitability of an existing port in relation to changing conditions came with the development of inland transport and the Industrial Revolution—the canal era and the concentration of industry on the coalfields—and then again later with the developments of the railway age. Where the port was so situated that it could utilise to the full these new means of communication it survived and expanded. But a still greater test was to come. Could the port adapt itself to the increasing size of the steamship? A harbourage of limited size, a rock-girt basin, a river channel liable to silting or difficult and expensive to dredge: these are factors which have resulted in the downfall of once significant ports. Whatever their original advantages, all the great modern ports have had to adapt themselves to

changing conditions. Two factors are absolutely essential to this development. The first is the suitability of the site to adaptation, the second the existence of sufficiently wealthy or powerful interests to carry out the actual work of organisation and construction. The one, it should be noticed, is useless without the other. It is significant how often the geographical factor which originally rendered the site of value or of importance as a port, as for example the existence of a small safe anchorage or pool at Liverpool and Hull, has become, with the changing requirements of shipping, of very little importance, and has passed both out of existence and out of knowledge.

The years since 1950 have witnessed the influence of a new technological

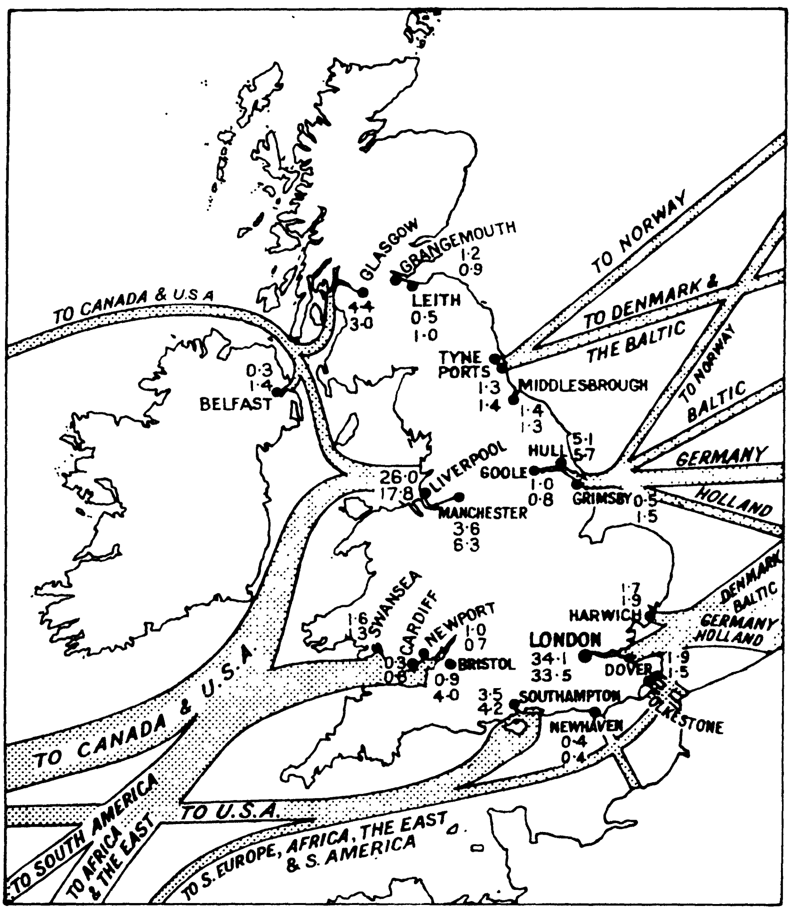



FIG. 249. General map of the Ports of the United Kingdom showing the proportions of the total export trade (upper figures) and import trade (lower figures) handled by each in 1960. Compare the 1967 figures given on pp. 721–2.

Some attempt is made to show the countries *principally* served by each port. It should be noted that most of the passenger and cargo liner services with South America are now from London with Southampton of lesser importance.

factor in the phenomenal increase in the size of oil tankers and other bulk carriers. The enormous size and deep draught of these vessels has led to considerable new port developments such as the creation of oil terminals in Milford Haven, the dredging of the approaches to Fawley on Southampton Water, the construction of a new oil terminal at Tranmere on the Mersey, the creation of deep-water ports at the mouth of the Tees and on the southern shores of the Humber estuary, and the construction of an entirely new port at Port Talbot to take large iron-ore carriers.

In the sections that follow the history of each port is briefly traced in order to show how the adaptation to changing economic and technological circumstances has been effected.

## London

There is little doubt that London was a port as soon as it was a settlement. Below the site of London the banks of the River Thames were low and marshy and unsuitable for building, and we have seen how the settlement grew up where firm ground approached sufficiently near to the river and where there was also a possible fording place. Those who know London at the present day find it hard to believe that the Thames was ever fordable in the neighbourhood, but one must remember that man in the last 2000 years has consistently been training the river into a narrow channel, whereas in early times, especially over what is now the Surrey side around Southwark, the waters must have wandered over a very wide area, and have been correspondingly shallow. From the early settlement trackways radiated to different parts of the country both to north and to south of the river, and there can be little doubt indeed that the early inhabitants of London had their primitive boats on the River Thames and that London was, therefore, a meeting place of land and water routes and a port. We may go so far as to say that the history of the port of London falls into four stages:

(*a*) the early period (to the Norman Conquest)
(*b*) the medieval period to the eighteenth century
(*c*) the nineteenth century—the great dock building era
(*d*) the modern period dating from the establishment of the Port of London Authority in 1908.

### The early period

The estuary of the Fleet as well as the well-known Pool of London below London Bridge must have afforded excellent anchorage for ships, and there is certainly no lack of evidence that Londinium was an important commercial centre much frequented by merchants and trading vessels at the time of the Romans. These facts are recorded by Tacitus in A.D. 61. It was natural, therefore, that London should later become the chief town of the East Saxons, and that in the eighth century the Venerable Bede should

describe it as a market of many nations whose traders came to it both by sea and by land. Later, London fell into the hands of the invading Danes from whom it was rescued by King Alfred the Great who, by encouraging the building of ships, helped materially the commerce of the port.

## The medieval period to the eighteenth century

There seems little doubt that London benefited on the whole from the Norman Conquest, for it was brought into closer relationship with the then more advanced countries of Europe. Merchants from France and from Flanders, as well as from more distant countries, came and settled in London and developed the city's foreign trade. The construction of the Tower of London by William the Conqueror illustrates the importance that was attached by the Normans to the stronghold. Even before the Norman invasion bands of German merchants had settled in what is now the area of Billingsgate, and it was from the descendants of these German settlers that the Hanseatic League developed. The centuries succeeding the Norman Conquest are marked especially by the development of the Hanseatic League (which had its headquarters where Cannon Street station now stands) and by the stranglehold which it gradually obtained over the commerce and shipping of the port of London. With the discovery of America by Columbus in 1492 the great age of exploration began. As early as 1505 the Merchant Adventurers was incorporated, and this association of Englishmen rapidly became a great band of merchant shipowners as well as trading adventurers. The English merchants rapidly became so strong that in 1598 the Hanseatic League was expelled from the country by Queen Elizabeth. The sixteenth and seventeenth centuries witnessed a great development of English foreign trade and with it the development of the trade of the port of London. The Russian Company, the Turkey Company, the East India Company, the Hudson's Bay Company and other concerns came into existence during this period, particularly under the stimulus of promises of monopolies to those companies which first opened up communication and trade with new or undeveloped countries. There is no doubt, too, that London benefited by the sack of Antwerp in 1585, since Antwerp was at that time the centre of European trade, and one is justified in saying that from that event onwards London became the commercial and financial centre of the world.

During this time London was a great river port. The small ships were beached or anchored by the side of the stream and their cargoes off-loaded in that position. Later it became desirable or necessary to construct small wooden piers or wharves of stone and wood at which the vessels could lie to be discharged or loaded. Alternatively, rectangular areas of the river bed were excavated, and the sides shored to prevent them slipping inwards. Such was the origin of Queenhithe and Billingsgate. Queenhithe—on the north bank above Southwark Bridge and so, like the Fleet anchorage, some

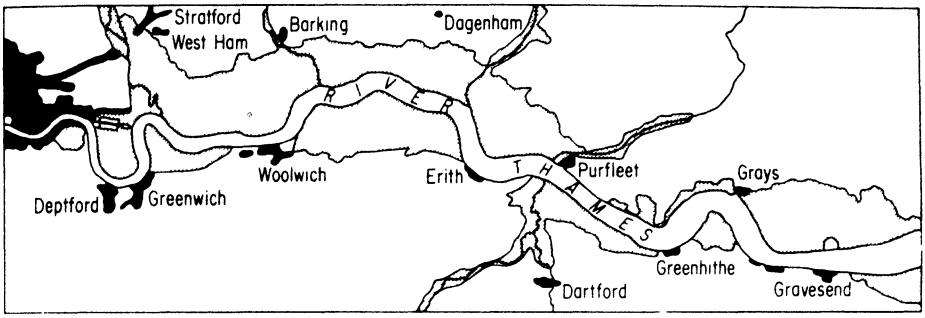



FIG. 250. Riverside settlements on the Thames below London in 1802

The stippled area is the alluvial flood plain practically without any habitations at this date. All the riverside settlements were on bluffs where firmer rocks reached the river side

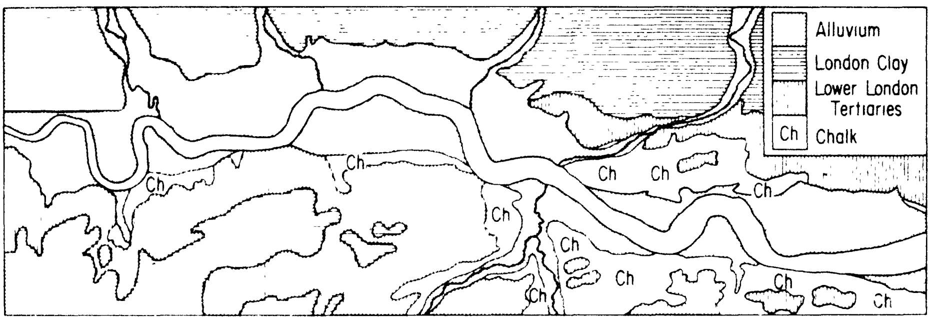



FIG. 251. The geology of the Thames Valley below London

Comparing this map with Fig. 250 it will be seen that the majority of the early riverside settlements are where the chalk affords firm ground

distance above London Bridge, was probably the first. Old London Bridge, with its double lines of shops and houses and its numerous narrow arches, played an important part in limiting the activities of the port. The rush of water through the narrow arches, both with the flow and ebb of the tide, was so severe that navigation was virtually limited to small boats and then to short periods of the day when the water was comparatively slack. Thus the port developed below London Bridge, and it is significant that all the great docks of the Port of London today are in the area below London Bridge. London Bridge is, indeed, the head of ocean navigation (except for colliers and craft of comparable size up to about 2800 gross tonnage able to pass under the arches of the bridge) on the Thames today just as it was 500 years ago. The Great Fire of London in 1666 destroyed most of the wharf and warehouse accommodation existing up to that time, and the reconstruction was on improved lines. The quays built were of two types: the legal quays where loading and discharging were permitted only in daylight under conditions enforced by the Commissioners of Customs and the sufferance wharves established by occasional licence to relieve congestion at the legal quays.

It was during the eighteenth century that the greatly increased trade of the Port of London demonstrated the insufficiency of the accommodation then available. Continuous congestion of shipping in the river itself resulted in great delay, loss, and inconvenience. It was difficult to protect vessels lying at anchor in the stream from plunder and from smuggling, and smuggling assumed huge proportions. Although a committee was appointed by Parliament in 1796 to inquire into methods of improving the port, it was the West India merchants who drew up practical proposals for the improvement of conditions. They laid it down as an axiom that any future development of the port depended upon the construction of wet docks.

## The nineteenth century

There was thus initiated the great period of development in the nineteenth century which may be described as the dock building era. The scheme of the West India merchants was to construct two docks on the Isle of Dogs. The plan was sanctioned by Parliament, and the West India Docks were opened on 27 August 1802. They were the first docks as understood today to be opened in the Port of London. The Howland Dock at Rotherhithe had been opened in 1696, but it was only intended for the safer anchorage of ships and, indeed, trees were planted as far as possible all round it in order to break the force of the winds. What had previously been regarded as the curse of London was now to be its salvation. For below the site of London, stretching practically to the sea and to a large extent along both banks, were enormous stretches of useless marshland, unsuitable alike for settlement and building, and for reclamation by the agriculturalists; this land for the most part had been lying entirely waste. Thus there were huge tracts where enormous docks could be constructed. Further, the land was a soft alluvium easily excavated, and below that gravel and London Clay[1] which also presented little difficulty. The land to start with was at river level. The London Clay did not present difficulties in the construction of docks which a very pervious substratum might have done; but at the same time the solid

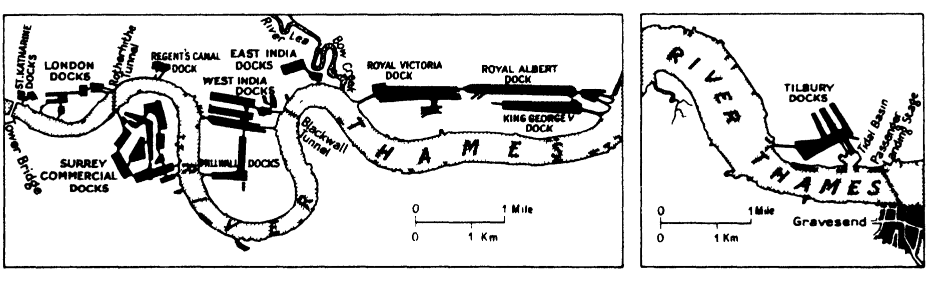



FIG. 252. The docks of the Port of London

Comparing this map with Figs 250 and 251 it will be seen that all the docks have been excavated in the previously uninhabitated flood plain in the tracts of alluvium.

1. But Chalk, not London Clay, underlies the alluvium at Tilbury.

clay was sufficiently firm for the foundation of quays and warehouses and, later, for great buildings such as flour mills. The London Dock was opened in 1805, the East India Dock in 1806, the St Katharine Docks in 1828, the Royal Victoria Dock in 1855, the Millwall Dock in 1868, and the Royal Albert Dock in 1880. That curious collection of docks, now known as the Surrey Commercial Docks, came into existence piecemeal between 1807 and 1876. At a later stage came construction of what is really the outport of London, Tilbury Docks, which were opened in 1886. In addition to the docks there were numerous riverside wharves and warehouses. The docks, warehouses, and wharves were built and owned by different companies. There was little coordination; instead destructive competition was the usual rule. Companies found themselves with insufficient resources to carry out the improvements and reconstruction which the growing size of steamers demanded. Towards the close of the nineteenth century there was a very real danger than London might pass into the position of only a second-class port.

## The modern period

But the danger passed, when, it is true, after a considerable delay, Parliament passed the Port of London Act in 1908. This Act created a new authority, a public trust the Port of London Authority—which was to take over and administer all the docks and the whole of the tidal portion of the river Thames between Teddington and a line about 113 kilometres (seventy miles) to the east across the estuary. The PLA, as it is usually called, has thus jurisdiction over the docks and their associated warehouses and storage yards, but on the main river itself the limit of the Authority's jurisdiction on both banks of the river is the high-water mark. Thus there are numerous quays and wharves lining the river which are privately owned, the best known of which is perhaps Hay's wharf. In the river itself the duties of the Port Authority include all matters relating to navigation, regulation of traffic, and the maintenance of adequate river channels; and undoubtedly one of its most important works has been the improvement of the river channels. In 1909, just after the Port of London Authority took charge, the deepest draughted vessel that had used the Port of London up to that time drew 8.2 metres (27 ft) of water. Now vessels which draw up to 11.2 metres (37 ft), the normal draught of the largest vessels in the world (other than supertankers), can use the Port of London. Fairly large seagoing steamers can ascend right to the Pool of London, to London Bridge.

## Outstanding features

We can now proceed to examine some of the outstanding features of the Port of London. One of the most remarkable features is undoubtedly the extensive use of lighters or barges. Despite the enormous area of wharfage accommodation, something like four-fifths of all the cargo reaching the

Port of London is off-loaded into lighters or barges, of which there are about 7000 on the waters of the Thames. The owners of these lighters or barges still have the rights which were given to their predecessors when the first docks were sanctioned by Parliament. They can enter or leave any of the docks belonging to the Port of London Authority and remain free of dues for seventy-two hours, if engaged on bona fide business. They are continually plying between the docks and wharves and the factories which line the 225 kilometres (140 miles) of banks of the River Thames. Most barges are towed by motor and steam tugs. Only a few of the old sailing barges remain, whilst a comparatively small number are self-propelled. Although coal can be delivered by colliers of moderate size which are able to pass under London Bridge to such points as the Battersea power station, many riverside works above London Bridge depend upon the continued use of the barges. In the second place London illustrates remarkably well that the successful modern port must not only be well equipped for handling all types of general cargo, but must have the special equipment necessitated by special types of cargo. It is one of the features of the London docks that there is marked specialisation in the cargoes handled by the principal docks. Then there is no doubt at all that the Port of London derives an enormous benefit from its huge storage accommodation, for it enables the Port of London Authority to act as warehouseman, more especially of goods which are subject to heavy customs dues. Merchants and wholesalers can rent storage space in the Port of London Authority's warehouses, or can pay so much for the storage of goods, and thus defer the payment of customs duty until the goods are actually required and can be cleared. Thus enormous quantities of tobacco are normally stored. Further, there are facilities for the cold storage of meat and other commodities requiring very specialised storage conditions unrivalled by any individual firm. For these reasons London had formerly a virtual monopoly of several types of imports into the country, such as tea and rubber. The destruction of warehouse accommodation, however, altered this position, which has never been quite regained - though the proportion of the country's re-exports handled by London remains high (see also p. 718). The table opposite shows the percentage of different imports into the United Kingdom which were handled by the port in 1929 and 1967.

The Surrey Commercial Docks deal with the greater part of the still largely seasonal timber trade. Storage accommodation is provided for nearly half a million long tons, and there are specially constructed sheds where timber can be seasoned, and, in addition, ponds for floating. The London and St Katharine Docks were those situated just below Tower Bridge—that is, nearest to London Bridge. As they were small, without direct rail connections, they could not be extended and used by large vessels, and were concerned mainly with coastwise and continental including Mediterranean trade, and St Katharine Docks closed in 1969. The storage arrangements here have been specially made for the more valuable

*Percentage of UK import trade in various commodities handled by London, 1929 and 1967*

| COMMODITY | 1929 | 1967 | |
|---|---|---|---|
| Meat | 48 | 43 | (Meat and meat preparations) |
| Grain and flour | 24 | 21 | (Cereals and cereal preparations) |
| Wool | 45 | 9 | (Textile fibres) |
| Butter | 44 | 33 | (Dairy products and eggs) |
| Wood | 31 | 24 | |
| Crude mineral oil | 50 | 16[1] | |
| Vegetable oils | 35 | 25 | (Animal and vegetable oils) |
| Tea | 93 | 72 | |
| Non-ferrous metals | 38 | 23 | |
| Iron and steel | 22 | 31 | |
| Hides and skins | 43 | 24 | (Hides, skins and furs) |
| Paper | 50 | 26 | (Paper and pulp) |
| Tobacco | 30 | 30 | |
| Rubber | 80 | 29 | |

[1] The drop in the proportion of imported crude oil is merely relative because only small amounts of oil were refined in this country before the war. The Port of London embraces the great Thameshaven-Shellhaven and Isle of Grain groups of refineries, with almost a third of the UK refining capacity. This has resulted in a phenomenal postwar rise in the imports of crude oil into the port as is illustrated by the following figures (in million gallons): 1938, 82; 1947, 71; 1954, 2088, and 1966, 5696.

types of merchandise such as wine, spirits, spices, sugar, ivory, gums, and essences. Here it is interesting to note other functions carried out by the Port of London Authority. Samples of commodities are taken by their experts, and the sales in the City are based on these samples which are in a way guaranteed by the independent and unbiased Port of London Authority. Farther downstream there is the great loop of the River Thames which almost cuts off the once pastoral marshy area known as the Isle of Dogs. It was only in 1929 that the two separate series of docks, the West India and the Millwall, which occupy this area, were united. The West India Docks, the oldest docks of the Port of London, were constructed specially for handling cargo from the West Indies; and it is remarkable that more than a century and a half later the most important commodities dealt with at the West India Docks still come from the West Indies. Hardwood is another of the commodities handled by the West India Docks. The Millwall Dock specialises in the handling of grain, and it is here that the grain is sucked from the holds of vessels by pneumatic elevators and passed into the central granary, which with a capacity of 24 300 metric tons (24 000 long tons) holds sufficient grain for London's needs for at least a week. Farther downstream the East India Dock formerly handled large quantities of goods from the East, particularly tea and silk; but now deals only with small coastwise and near continental traffic. At Royal Albert Dock special ar-

rangements have been made for the banana traffic of London. Here, too, there is a disease-proof quarantine station established for pedigree stock for export to various parts of the world. The Royal Victoria, Albert, and King George V Docks are in reality one huge dock divided into three sections. They form the largest sheet of enclosed dock water in the world, with a total

PLATE 30. London river and the Royal group of docks
Note the sheaves of lighters moored in the river; and compare Fig 250

area of 445 hectares (1 100 acres), of which 95 hectares (235 acres) are water, and with 16 kilometres (10 miles) of quay. In these docks the water is kept at a height of 0.76 metre (2½ ft) above high-water mark. To the north of the Royal Victoria Dock are the storage warehouses, whilst to the south are four large flour mills. The Royal Albert Dock handles most of the meat imported by London, much of the meat being taken into huge cold stores which have

been erected to the north side of the dock, and which are capable of accommodating well over half a million carcasses of mutton. The King George V Dock was opened in 1921, and, with a depth of 11.6 metres (38 ft), it can accommodate vessels up to 35 000 tons gross (such as the *Mauretania*), despite the fact that it is comparatively near to the heart of London. Large vessels, such as the P. & O. liners of 40 000 tons, can be accommodated in the Tilbury Docks, where an entrance 305 metres (1000 ft) long and 33.5 metres (110 ft) wide was opened in September 1929, and where a magnificent dry dock was later completed. Tilbury handles most of the passenger traffic using the port of London, and there is a floating landing stage which can be used at all stages of the tide. It is served directly by rail and is within 45 minutes of the heart of London in addition to having easy communication with all parts of the country. Although built by the combined East and West India Docks Company, Tilbury might have developed into a separate 'outport' and rival of London itself, but the unification of control has prevented this. The latest development at Tilbury is the construction of a large container terminal.

Naturally the docks of London were a priority target for enemy bombing from 1940 to 1945; destruction, especially of warehouse accommodation, was great and the port was virtually unused. But the main structures remained and the docks have been restored. The damaged Poplar Dock was converted to a specialised oil-terminal in 1958.

We have indicated elsewhere how the once significant shipbuilding industry of the Thames has disappeared, and London illustrates rather well the separation of shipbuilding from ship repairing. The Port of London is

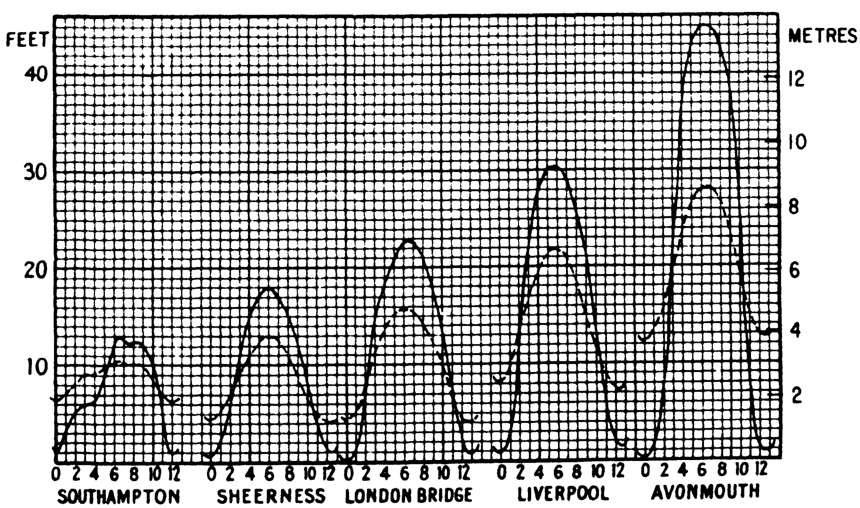



FIG. 253. Tidal graphs of some characteristic British ports

The two graphs in each case are for a typical spring tide and a typical neap tide. Figures below show the time in hours. Notice the effect of the double tide at Southampton and the small range; the increasing tidal range in the Thames as one goes from Tilbury to London Bridge; and the enormous range at Avonmouth.

very well equipped for ship repairing. It has no less than nine dry docks, including one at Tilbury which is 228 metres (750 ft) long and 30 metres (100 ft) wide and can, when the increasing size of vessels demands it, be extended to over 305 metres (1000 ft) in length. In these docks every facility for the repair and overhaul of vessels is provided. One very important factor in the maintenance of London's pre-eminence as a port is the close cooperation between the port and the commercial centres of London. This is possible despite, in fact one might say because of, the separation of London into zones of functional utilisation. Thus going westwards from dockland one comes immediately to the commercial and business centre of London—first to the network of narrow streets where are situated so many of the wholesale firms. This juxtaposition is responsible for the retention in London of a great woollen market—for so long and to some extent even now a world market—despite the fact that practically none of the wool is used for manufacture in the neighbourhood of London itself. Then there is very close connection between the Port of London and industrial London. On p. 678 we have given a map showing the situation of so many of London's industries along the banks of the Thames and the still important canal systems.

## Liverpool and Merseyside

If London has been a great port for 2000 years the same can scarcely be said of Liverpool, for the real rise to importance of Liverpool is within the last two hundred years. A thousand years ago, when London was already an important centre, Liverpool was just one of a group of small vills comprised within the ecclesiastical parish of Woolton in the Greathundred of West Derby. Both sparsely inhabited and comparatively unimportant was the region at the time of the Domesday survey, hence (because of its unimportance) the hundred of West Derby is one of the largest in the country. The greater part of the old parish of Woolton was situated on an islandlike upland, formed of Keuper and Bunter Sandstone, which the late Professor P. M. Roxby called the Liverpool Plateau. It was almost surrounded by low-lying land, originally 'mosses' or low-lying peatland which cut it off from the rest of Lancashire. Northeastwards a ridge of slightly higher land connected this islandlike site with south Lancashire through Prescot, and for a very long time the only carriage road lay along this ridge. To the southwest the plateau approached very close to the bottlenecked estuary of the Mersey. Liverpool was an agricultural township, but it had the advantage of a small tidal creek called the Pool, which extended inland for about half a mile from the site of the Customs House along the line of what is now Paradise Street and Whitechapel as far as the old Haymarket.

King John seems first to have visualised the possibilities of Liverpool as a port for Ireland—a military port in that case—and so made it into a borough in 1207. And it was from the quiet waters of the Pool that fishing and coastal traffic was built up, including a not inconsiderable trade with

Ireland. In these early days Liverpool was overshadowed by the importance of Chester—indeed, it was claimed as being merely a creek within the port of Chester. But, owing to the silting up of the Dee estuary which was specially marked from the fourteenth century onwards, Chester became unimportant as a port even before the rise of the trans-Atlantic trade which was destined to be of such significance to Liverpool. The great age of exploration initiated by the discovery of America in 1492 first gave Liverpool its real opportunity, but for long Bristol dominated in the western trade. There seems little doubt that the greater security of a route to the north of Ireland compared with the route to the south of Ireland was by no means unimportant in view of the long series of wars with Holland and France in the seventeenth and eighteenth centuries. Although the immediate situation of Liverpool rendered communication with its hinterland in Lancashire difficult, the importance of the Midland Gate which facilitated communication between the merchants of London and Liverpool soon came to be recognised. From the latter part of the seventeenth century the growth of the port was rapid. First came the recognition of Liverpool as the chief port for the Irish trade as far as the north of England was concerned, as well as for increasing coastal traffic with western Scotland. Then there was the rapid development of trade with the West Indies, infamously associated from about 1730 with what has come to be known as the great Trade Triangle and which dominated Liverpool shipping in the latter half of the eighteenth century. Ships from Liverpool sailed to West Africa with cheap manufactured goods such as beads, indifferent muskets, gunpowder, and raw spirits which they traded with the African slave-traders or so called 'kings', who organised slave raids into the interior. These same ships then took on board full cargoes of Negroes and made the famous middle passage with the help of the trade winds, disposing of the slaves in the West Indies, returning thence to Liverpool with a cargo of molasses, tobacco, and cotton. The abolition of the slave trade in 1807 did not, as many Liverpool merchants had anticipated, check the growth of the port. By that time the Industrial Revolution was in full swing, and there was a huge demand for raw cotton from the southern United States, and Liverpool became what it has since remained—the chief importing port for raw cotton. Then came the development of trade in cotton goods, particularly after the cessation of the monopoly of the East India Co., as well as the development of more varied trade with the North American continent and an emigrant traffic.

Just as in the case of London, it was found that Liverpool was so situated that she was able to adapt herself to changing requirements. The mouth of the old pool was converted into a wet dock—one of the first in the world—and the remainder of the pool filled in. There was a marshy fringe running along the side of the Mersey and bordering the sandstone plateau on which the settlement was situated, and this afforded possibilities for the excavation of docks just as the marshy land of the lower Thames had done. The docks were extended all along the waterfront southwards until the natural limit

was reached where there is an outcrop of sandstone on the river bank at Dingle Point. Here is the residential district of Aigburth. Beyond this are more marshes, and here has been developed the group of docks forming the port of Garston owned, before the nationalisation of the railways, by the London, Midland and Scottish Railway. To the north of Liverpool the limit has not yet been reached, and here it was claimed that the Gladstone group of docks when opened was amongst the largest and best equipped in the world. Further extensions were in progress in 1969. The development of docks along the whole waterfront has had two main results. The old shipbuilding yards have disappeared, and not only have the warehouses and mills been forced inland, but still more has industrial development. Few of the factories of Liverpool can be supplied direct from lighters as in the case of London or Hull, and so lighters play but a small part in the life of the port. Whilst the excellent arrangement in the port itself renders loading and offloading possible in very short time, the old overhead railway running the length of the docks enabled workers to get quickly to their work, but hindered the development of industries with direct access to the docks.

As in London the early dock construction was carried out by separate companies; but the need for a unifying authority was appreciated much earlier, and the Mersey Docks and Harbour Board came into existence in 1858. It now controls the whole dock estate on both sides of the river, except for the nationalised Garston docks which are under the Docks and Inland Waterways Executive. The rapid development of the whole waterfront of Liverpool rendered the utilisation of the Cheshire side inevitable, which happened in the middle of the nineteenth century—about the initial nucleus of Wallasey Pool, an inlet corresponding roughly in character with the old Liver Pool. There are now over 186 hectares (460 acres) of docks on the Liverpool side with a quay frontage of 43 kilometres (27 miles), and on the Cheshire side a water area of 73 hectares (181 acres) and 14.5 kilometres (9 miles) of quay. There is not as yet a continuous line of docks on the Cheshire side as there is on the Liverpool side, and so a considerable number of industrial concerns there have their own water frontage. There one finds also the shipbuilding yards, and the Tranmere oil jetty. Thus, on the Cheshire side, there has grown up the great industrial and commercial town of Birkenhead, and more recently the residential area known as Wallasey, which may fitly be described as a dormitory for both Birkenhead and Liverpool. Indeed the greater part of the Wirral Peninsula is rapidly becoming a residential area for Merseyside. Immense numbers of workers cross over morning and evening by ferry and by the Mersey railway from the Cheshire to the Lancashire side, and the need for the construction of the Mersey road tunnel (opened 1934) became apparent.

It has been pointed out that the Liverpool plateau is separated from the main part of Lancashire by a belt of low-lying 'moss', a large proportion of which is now extremely fertile agricultural land. This emphasises the isolation of the Liverpool region from the manufacturing and industrial

regions of south Lancashire, an isolation which is borne out by the character of the industries of Merseyside. For the major industries are based essentially on imported materials—milling, soap, and candle manufacturers, cattle-food industries, and so on. Liverpool shows to some extent the zoned character of London. In the rear of the docks there is the business part of the

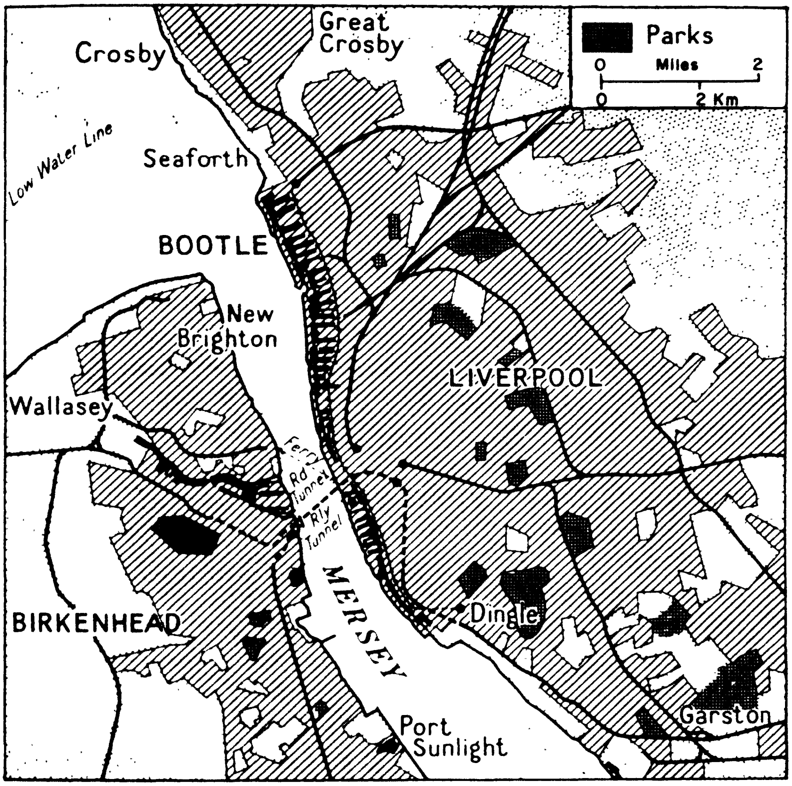



FIG. 254. The port of Liverpool

A unique feature of Liverpool's transport system was the electric overhead railway, supported on wrought iron columns about 6 metres (20 ft) from the ground which ran for 10.5 kilometres (6½ miles) alongside the docks, from Seaforth to Dingle, thus affording facilities for travelling from one part of the long dock estate to another. It was however closed on 31 December 1956 and has been dismantled. The famous road tunnel cost over £7 000 000 and was opened in 1934

city, concentrated especially round the Town Hall and coinciding very closely with the centre of the old township. Near at hand is what may be described as the social centre with fine public buildings such as the Picton Library, St George's Hall, the Walker Art Gallery, and many of the finest shops. Then, forming an irregular ring, is the residential area, some of it still consisting of extremely congested slums—a legacy of the early days of the Industrial Revolution which Liverpool has done her utmost to remove. On the high ground of the sandstone plateau stand the University and two cathedrals. The industrial development tends to be concentrated near a

labour supply, and as far as possible near the supplies of raw materials from the docks. In some cases the industrialisation is considerably removed from the centre of the city, as in the Aintree district, in the new estates of Kirkby, and at Speke and Halewood. On the Cheshire side lie two main areas of industrialisation. One is to the south of Birkenhead on low ground where the industrial area of Port Sunlight and the region around Bromborough Pool (converted into a dock in 1931) has been spreading right to the entrance of the Manchester Ship Canal. The second area is on the Great Float, the lower part of Wallasey Pool, where the Mersey Docks and Harbour Board hold land for future development.

*Percentage of UK import trade in various commodities handled by Liverpool*

| COMMODITY | 1948 PER CENT | 1967 PER CENT | |
|---|---|---|---|
| Meat | 26.1 | 10.7 | (Meat and meat preparations) |
| Grain and flour | 22.9 | 15.9 | (Cereals and cereal preparations) |
| Cotton | 84.0 | 45.9 | (Textile fibres) |
| Wool | 40.3 | | |
| Butter | 11.6 | 12.1 | (Dairy products and eggs) |
| Eggs | 21.5 | | |
| Wood | 37.0 | 10.7 | |
| Vegetable oils | 41.0 | 53.0 | (Animal and vegetable oils) |
| Tea | 25.3 | 19.9 | (Beverages) |
| Non-ferrous metals | 8.3 | 23.7 | |
| Iron and steel | 5.3 | 11.9 | |
| Hides and skins | 61.5 | 8.2 | (Hides, skins and furs) |
| Paper | 3.7 | 1.8 | (Paper and pulp) |
| Tobacco | 35.9 | 23.4 | |
| Rubber | 48.0 | 42.7 | |

It is quite clear from the above table—and indeed from the table on p. 722—that Liverpool's share of freight traffic has declined, in some cases quite seriously, during the last two decades. This is partly due to the increased emphasis in the nation's trade pattern on trade with European countries, for which east coast ports can cater more expeditiously, and to the declining relative importance of trade with the Commonwealth (see Fig. 290). Thus whilst the overall value of London's trade has trebled since 1948, that of Liverpool has not even doubled (see table on p. 719). The largest major category of imports is foodstuffs, including grains, sugar, meat (especially lamb, the beef trade having gone to London) and fruit; many types of raw materials come in, including cotton, wool, ores and crude metal of various kinds, especially tin and copper, and of course petroleum. The exports are really an epitome of British exports as a whole, with machin-

ery and transport equipment (especially motor vehicles of all kinds) as the major category, followed by manufactured goods including textiles, iron and steel, non-ferrous metals, and chemicals. Amongst the re-exports is Guinness beer imported from Dublin in coasters and sent out in oceangoing ships all over the world.

## Manchester

As an ocean port, Manchester only dates from 11 January 1894, when the Manchester Ship Canal, constructed between 1887 and 1893, was opened for traffic. The Manchester Ship Canal extends from Eastham on the south side of the Mersey to the heart of Manchester,[1] and has a total length of 57 kilometres (35½ miles) and a minimum depth of 8.5 metres (28 ft). Docks at Eastham have been reconstructed to take tankers up to 30 000 tons and the new Tranmere jetty still larger ones. Vessels of up to 10 000 tons can go the whole length of the canal. The bottom width of the canal at the full depth is, with a very few exceptions, 36.5 metres (120 ft). This is sufficient to allow large ships to pass one another, and at the bend at Runcorn the bottom width has been increased to 47 metres (155 ft). In Manchester itself, the Trafford Park industrial estate has developed adjoining the docks. In 1894, the first year that the port of Manchester was opened, the value of the trade was £6.9 million sterling, of which about 40 per cent represented imports. The trade had grown tenfold in value by 1929. The capital expenditure on the canal by the end of 1914 was nearly £17m. and it was not until 1915 that the first dividend was paid on the preference stock. The canal extends between two of the busiest industrial regions of Britain, and several important industrial sites are now located along its banks, including Trafford Park at the Manchester end, Irlam iron and steel works, several at Runcorn, and of course the great Stanlow oil refining and petrochemical complex near the western end (Fig. 255).

The port of Manchester (which for statistical purposes includes the whole of the Ship Canal) is now the fourth port of the United Kingdom in terms of the value of its trade though its imports greatly outweigh its exports. The most important individual items in recent years have been imports of petroleum and of refined copper (for the Lancashire engineering and cable-making trades), but there are considerable imports of foodstuffs (especially maize), tobacco, pulp and paper. The exports, naturally, are of manufactured goods and machinery, including textiles (with woollens much more important than cottons), textile machinery, electrical machinery and vehicles, and petroleum products.

## Hull

Hull is an example of a port whose commerce has been continuously active, and whose position in relation to other English ports has changed very little

1. Most of the docks are actually in Salford.

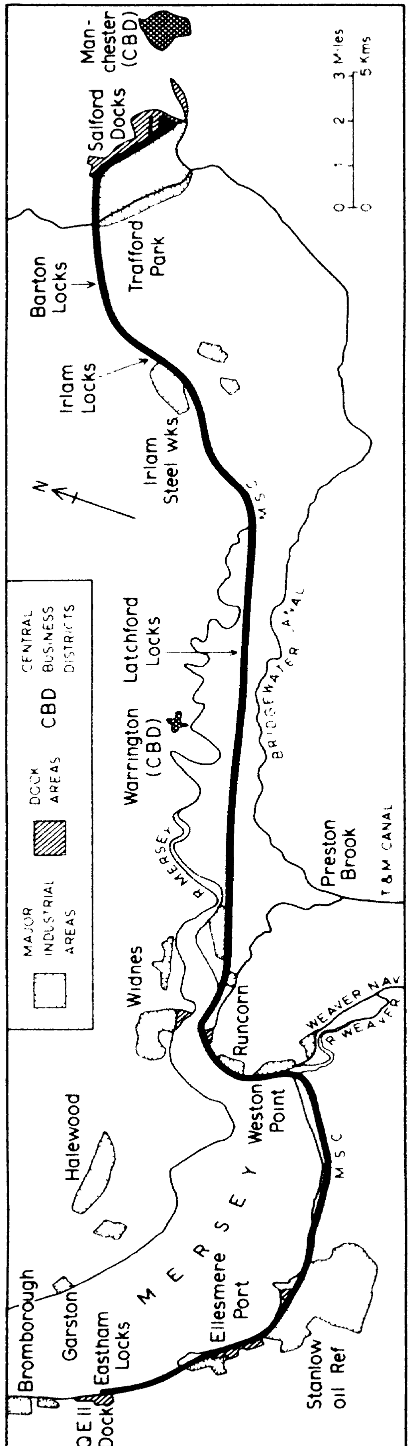



FIG. 255. The Manchester Ship Canal

since the Middle Ages. In this respect Hull can be compared with London. Again, we have an example of a port where geographical surroundings permitted its adaptation to modern conditions—as in the cases of London and Liverpool. By way of contrast other ports of the vicinity were not so fortunate. In the thirteenth and fourteenth centuries the commerce of Boston, which was the outport of Lincoln, exceeded that of Hull, but is now entirely insignificant. The possibility of development was precluded for one reason by the silting up of the approaches to Boston. The port of Hedon flourished in the twelfth and thirteenth centuries and stood, like Kingston-upon-Hull, on a tidal creek of the Humber to the east of Hull. But it was too far inland for the approach of modern vessels and suffered, again, from the choking of its channels. Finally, Ravenserodd, formerly situated on a small sandbank behind Spurn Point, entirely disappeared in the middle of the fourteenth century a victim of the tidal scour which somewhat earlier had created the very land on which it was built.

The little River Hull enters the Humber from the north just where the line of the Humber curves northwards in such a way that the river current and the tidal current hug the shore and guarantee permanent deep water. The river Hull is navigable for some distance to the north, and, as is so frequently the case, near the head of navigation a small port and town sprang up—the town of Beverley- situated some distance away from the marshy banks of the river itself with which it is connected by an artificial channel. The first stage in the history of the rise of the port of Hull was when the little creek offered shelter or anchorage for boats on their way to its older neighbour Beverley. A little marsh-surrounded settlement grew up to the immediate west of the mouth of the creek, and it was Edward I who, in passing through this little settlement, caused it to be known as King's Town upon Hull (Kingston-upon-Hull is still the full name of the city of Hull), and granted the town its first charter. A plan of Hull dating from the fourteenth century shows a small settlement with quays on the east at which sailing boats are being unloaded with the help of hand cranes, and the settlement guarded on the north, west, and the south by a wall outside of which is a moat connecting the waters of the Hull with the waters of the Humber to the west of the settlement. A glance at a physical map will show that Hull is situated on the Humber a few miles to the east of the point where the river cuts through the chalk escarpment. To the west, the northwest, and the southwest lies the Trent and Ouse Basin: in all covering an area of about one-sixth of the whole of England. Most of the rivers of the basin were navigable for considerable distances. Doncaster was about 5 kilometres (three miles) above the old limit of navigation of the Don and York lies near that of the Ouse. Thus, in early days, a place of shelter near the mouth of the Humber could not compete with the ports which were situated well inland along these navigable rivers (cf. Fig. 258).

The second stage in the development of the port came with the increasing size of oceangoing vessels. Hull became the point of transhipment for river

craft trading with towns on the navigable parts of the Ouse and Trent system. It clearly had the advantage of position, and could fulfil this function in a way in which Beverley could never do. So Beverley gradually became what it is today—a small town constructing trawlers for the fishing industry of Hull. The appalling condition of roads in England gave Hull a very considerable importance as an outlet from all central England, even for goods from such areas as Cheshire and Lancashire destined for London.

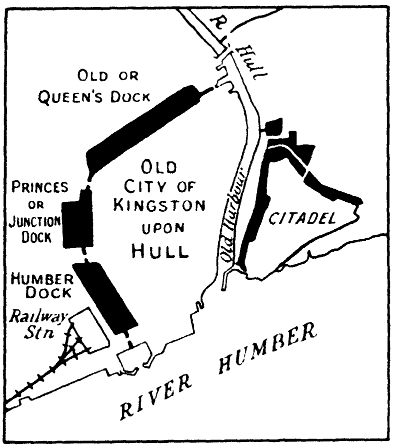



FIG. 256. The port and docks of Hull in 1840

The third stage in the development of the port came with the canal era, when the natural waterways were improved by a network of canals, of which the Aire and Calder was, and remains, the most important, which brought the growing industrial centres, particularly of West Riding, into easy communication with Hull. Thus the outstanding features of the port of Hull today—especially the immense amount of transhipment into lighters for distribution—developed at an early date. Further, Hull is still unique amongst the ports of the British Isles in the extent and significance of inland water navigation from its docks.

The fourth stage in the development of the port came with the construction of docks. As Rodwell Jones has said, 'the increase in size of vessels together with the increasing volume of trade made it necessary to supply means whereby ships could be in harbour for considerable periods without grounding, and cargoes could be dealt with at quaysides without change of level, since the tidal range at Hull is about 19 feet'. The old wall and moat became the site of the earliest docks. The Queen's Dock or Old Dock was opened in 1778, Humber Dock in 1809, Princes or Junction in 1829. The coming of the railway is emphasised by the name Railway Dock—a small offshoot from the Humber Dock opened in 1846. The earlier line of approach to Hull by railway (from Selby, opened in 1840) followed along

the Humber where there was sufficient space between the chalk scarp and the river to obviate the necessity of constructing a tunnel. A later line which approached the town from the northwest had to cross the chalk scarp; the gradients were considerable, and there was also a tunnel. Marshy, unoccupied land to the southeast of the town has provided further opportunity for the construction of docks, and there followed here the Victoria Docks (1850). Subsequent dock construction resembled that at Liverpool in that it extended along the extensive water fronts, but it differs somewhat in the methods adopted. For farther to the southwest the work was carried out by constructing a great embankment along the line of the estuary and thus producing behind it the St Andrew's Dock (1883), the Albert Dock, and William Wright Dock (1869), these three being to the west of the town. Of necessity, later development had to be farther downstream, where there is the giant Alexandra Dock opened in 1886, and the King George V Dock opened in 1914 and enlarged in 1959–62. At first it is to be noticed that railway construction merely emphasised the existing lines of communication, and amongst the early disconnected portions of railway construction, that from Hull to Selby, and the industrial West Riding, was both noteworthy and early.[1] Subsequently railway construction extensively widened the hinterland served by the port. It is interesting in this connection to notice that with the regrouping of British railways in 1923, Hull became pre-eminently the port of the London and North Eastern Railway.

The value of the export trade has never afforded a very good index of Hull's importance because of the great bulk of coastwise traffic and the large fish trade. Since the fish is landed from British-based ships it does not figure as an import. The port resembles London in the very general nature of cargoes handled, and in that it is primarily an importing port, particularly of foodstuffs. Hull is the leading British port for the import of oilseeds. The seed is sent by lighters from the deep water docks to the crushing mills along the Hull itself and also to Selby. Similarly with wheat, of which there is a huge import; one finds flour mills (with the seed-crushing mills) lining the banks of Hull for something like two miles. The concentration of flour milling at the great ports of the British Isles is a very marked feature and has been responsible for the decay of milling in many smaller towns. For example, some of the wheat imported at Hull was formerly sent for milling at York, but later the York mills were closed. There is a large import trade in butter and bacon—obviously connected with Hull's suitability for distributing these commodities to the large industrial population of the north of England, and also obviously connected with the situation of Hull with regard to the continental ports, including those of Denmark, from which these commodities are exported. Similarly with the huge imports of timber—partly the result of the connection of the port with the great coalfields, and partly because of its position in relation to the European

1. See Fig. 240.

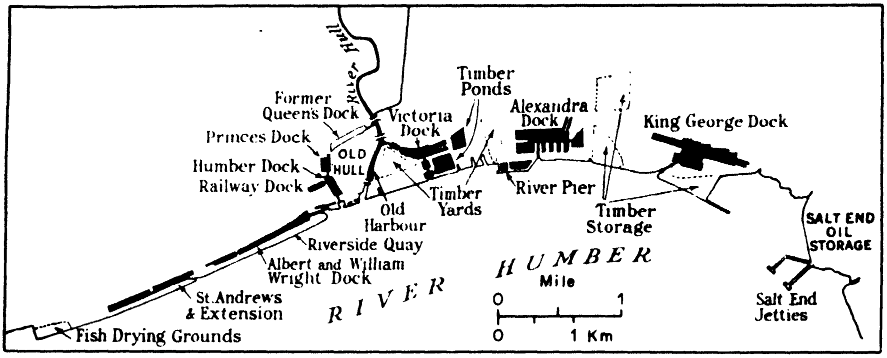



FIG. 257. The port and docks of Hull. Queen's Dock had outlived its usefulness and was filled in to form an open space in 1934

countries from which much of the timber is derived. As a wool importer Hull is second to Liverpool, for the latter has better regular shipping connections with Australia, New Zealand and other wool-producing countries than does Hull. Petroleum products are imported at the Salt End jetties, especially for the adjacent chemical works.

As an exporting port Hull is largely concerned with the products of its hinterland, whilst the nature of the commodities is also influenced by the continental destination of much of the exports. Vehicles, textile machinery, manufactured goods including textiles, non-ferrous metals and iron and steel products, chemicals, and also wool, wool tops and yarn, figure largely in the total.

Something has already been said of the immense importance of Hull as a fishing port (pp. 261–2). The majority of Hull trawlers are big vessels, often absent for several weeks at a time, and therefore requiring large stocks of fuel and ice, and really excellent facilities for handling the catch when they reach port. The St Andrew's Docks are entirely given over to this traffic.

Hull had more than its share of bombing and the heart of the city was virtually eliminated. In plans for reconstruction land transport presented a major problem. The main docks are and must remain to the east of the city, the hinterland lies to the west. Railways crossed roads by a very large number of level crossings. Tunnelling is difficult because of a high water level in the alluvium: a succession of viaducts would be extremely expensive. The Humber cuts Hull off from direct communication with the south and a road–rail bridge has long been proposed.

## Grimsby, Immingham and Goole

It has been pointed out that the development of Hull as a port is closely bound up with its extensive hinterland and the waterways therein. It is clear that, provided deep-water facilities for oceangoing vessels are available, there must be other sites on or near the mouth of the Humber which

could also handle the traffic of the same hinterland. There are now three ports which share with Hull the Humber trade—Grimsby, Immingham, and Goole. Grimsby lies to the south of the estuary of the Humber in the county of Lincolnshire, 27 kilometres (seventeen miles) southeast of Hull.

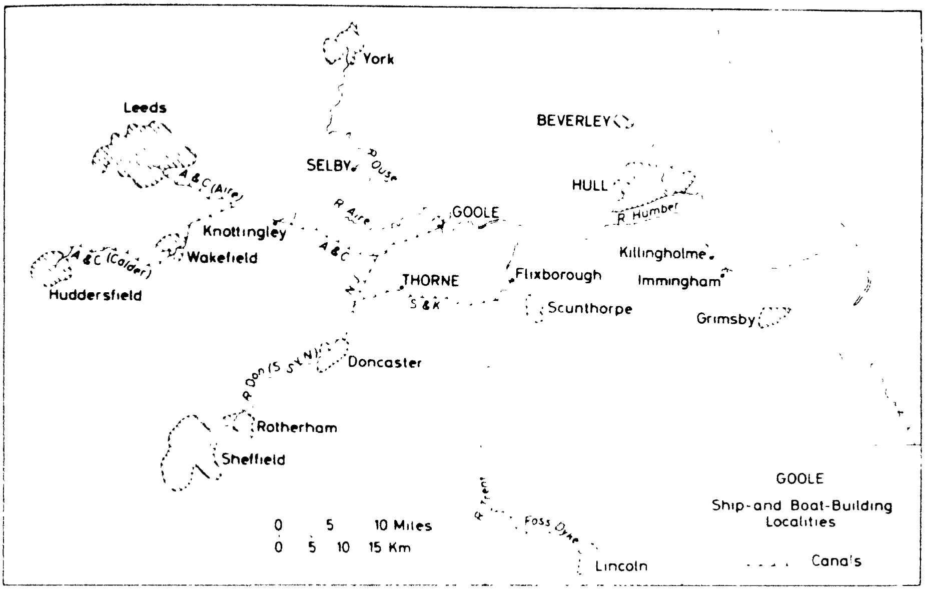



FIG. 258. The Humber ports and their inland waterway connections
The ship- and boat-building localities have been specially distinguished (cf. p. 431)

The potentialities of the site had long been apparent, but the development was left to the railways in the 1850s when the initiative of the Manchester, Sheffield, and Lincolnshire railway, later part of the London and North Eastern system, began the transformation of a fishing village into a town of over 100 000 inhabitants. Grimsby is, of course, pre-eminently a fishing port, handling a quantity of fish which in interwar years reached nearly a quarter of a million tons (cf. p. 264). There was a steady development of the fish traffic in the latter part of last century, but it was not until 1900 and the opening of No. 2 Fish Dock that an enormous extension of the fish trade took place, and in the early decades of the present century the fish expresses to all parts of Great Britain were a characteristic feature of the port. A third fish dock was added in 1934.

The entrance to Grimsby Docks is through a tidal basin into the Royal Dock and its Alexandra extension, and through locks into the Fish Docks. Moreover, the main channel of the Humber does not swing along the coast here and there is a large stretch of mud at low tide. Eight kilometres west of Grimsby, however, there is a position where the main deep-water channel approaches the shore. Here, in 1912, Immingham Dock was created by the former Great Central Railway. For various reasons, mainly the economic

disturbance resulting from the First World War and the depressions of the 1920s and 1930s, Immingham, despite a large coal export and iron ore and timber import, never lived up to the expectations of its promoters, and it is only in the last decade or so that with the increasing industrialisation of south Humberside, it has come into its own, to serve in particular the oil, chemical and fertiliser industries. New oil jetties were constructed in 1963, and nearly half the total import tonnage is now crude petroleum for the Killingholme refinery.[1]

The foreign trade of Grimsby and Immingham is combined in the official statistics, but in fact Immingham deals mostly in mineral and timber traffic. The trade of the combined port is somewhat unbalanced, imports far exceeding exports in value. Amongst the imports foodstuffs, mainly bacon and butter from continental sources, are of high value, whilst iron ore, other minerals (including sulphur for local chemical works), timber (including pit props) and of course crude oil, represent a greater bulk. There is also an import of fish landed from non-British (e.g. Icelandic and Norwegian) vessels. Of the exports, coal is still of some significance both in bulk and in value, while petroleum products, chemicals, iron and steel products and machinery figure prominently.

Grimsby and Immingham were both, from 1923 to 1948, on the London and North Eastern Railway system; the corresponding port on the London Midland and Scottish Railway was Goole, 80 kilometres (fifty miles) from the open sea on the river Ouse but still accessible to vessels of 1000 tons. Goole is directly connected to Leeds by the Aire and Calder Canal system which, with its trains of compartment boats, is one of the most important inland waterways in the country. Its trade is largely with continental ports, and includes imports of timber, foodstuffs, fertilisers and some wool and other textile fibres, with exports of manufactured goods including wool tops, textile fabrics, metal goods, chemicals and coal.

## Southampton

Southampton is the chief commercial port on the south coast. Although the Docks are of comparatively modern origin, dating from 1842, the port itself has played a long and notable part in the history of Britain. In A.D. 43 the Romans established a station on the east bank of the River Itchen; the Norman Conquest established it as the port for the royal city of Winchester, then capital of England, and by 1450 Southampton ranked as the third port of Britain.

Good geographical position and natural advantages have contributed to making Southampton a foremost port. Situated in the centre of the south coast, within easy reach of London and the continental ports of Havre and Cherbourg, the Docks stand at the head of Southampton Water, a well

1. See R. V. Leafe, 'The port of Immingham', *E. Midland Geog.*, **4**, 1967, 127–42.

sheltered estuary leading from the English Channel, with the Isle of Wight forming a natural breakwater at the entrance. The approaches to the Docks enjoy a great natural depth of water, in fact it was not until 1882 that dredging had to be resorted to for deepening, but with the advent of the big ocean liners, drawing up to 11.9 metres (39 ft) of water, dredging has, of course, been necessary, and today the main channel of Southampton Water is 244 metres (800 ft) wide with a minimum depth of 10.7 metres (35 ft) at low water. The advent of the giant oil tanker made further dredging of the approaches to Southampton Water necessary, to a minimum depth of 13.7 metres (45 ft), in order that vessels of 80 000 tons, drawing 14.3 metres (47 ft) when fully laden, might reach the Fawley refinery.

PLATE 31. The port of Southampton
Compare Fig 260

Another natural advantage is the relatively small tidal range of only 3.9 metres (13 ft), making closed docks unnecessary, but undoubtedly the greatest natural advantage which has aided Southampton is the phenomenon of a double high tide whereby the period of high water is maintained for two hours twice during the twenty-four hours. In addition, there is the 'young flood' stand, which is an interruption of normal tidal rise causing a slack-water period occurring from 1½ to 3 hours after low water; thus during

the twenty-four hours of each day there are seven hours slack water at a level navigable by all types of ships. Various theories[1] have been advanced as to the cause of the double tides and the unusual feature of such a short ebb but no one theory completely accounts for all the features experienced in the port.

The modern system of docks at Southampton was not started till 1838, when a small group of business men, realising the potentialities of Southampton as a port, founded the Southampton Dock Company, and the first dock was opened for trade in 1842. Well-equipped quays were laid out in such a way that passengers and cargo could be brought from and sent to London and other inland destinations with the maximum of speed. In 1892 the Docks were transferred from the Southampton Dock Company to the London and South Western Railway (later the Southern Railway) and in 1948 passed to the British Transport Commission, being subsequently placed under the control of the Docks and Inland Waterways Executive (now the British Transport Docks Board).

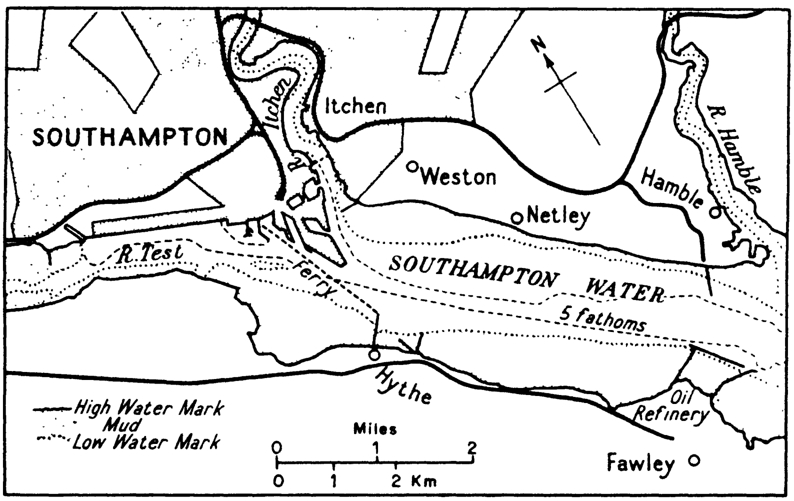



FIG. 259. The port of Southampton

Some measure of the prosperity the Docks have brought to Southampton is shown in the growth of population of the town, from 65 621 in 1892 to 180 000 in 1953 and 204 707 in 1961.

The Old Docks, covering some 80 hectares (200 acres), form a triangle with the apex at the confluence of the rivers Itchen and Test. In addition to the river quays there are three large tidal basins, the Ocean Dock, Empress Dock, and Outer Dock. The Ocean Dock is the main base of the

1. F. H. W. Green, 'Tidal phenomena, with special reference to Southampton and Poole', *Dock and Harbour Authority*, Sept., 1951. See also J. H. Bird, *The Major Seaports of the United Kingdom*, pp. 164–8.

North Atlantic express passenger services, and the Ocean Terminal, a double-storey passenger and cargo reception station on the eastern side of this dock, completed in 1950, after severe wartime bombing and destruction of older installations, is acknowledged to be one of the best of its kind in the world.

To the northwest of the Old Docks, facing the River Test, are the New Docks, begun in 1926, completed in 1934. A bay of 160 hectares (400 acres) of tidal mudland was reclaimed to give a straight line of 2½ kilometres (1½ miles) of deep water quay, with adjacent passenger and cargo sheds, railway sidings and appliances for the rapid handling of passengers and freight. At the western end of the New Docks is the King George V dry dock, which at the time of its construction in 1933 could accommodate vessels larger than any yet built, and which was regularly used by the *Queens* of 80 000 tons in later years. Immediately behind the New Docks quays are 52.5 hectares (130 acres) of reclaimed land which is gradually being developed as an industrial estate.

Southampton is Britain's premier passenger port, dealing with about

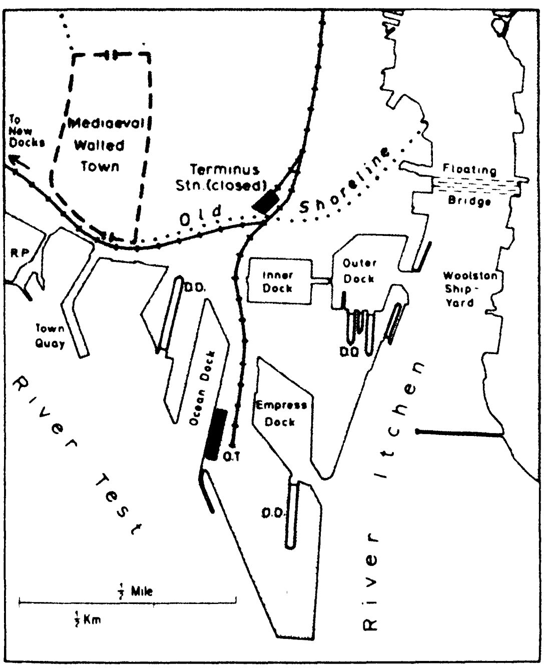



FIG. 260. The older docks of Southampton

Note the relation to the medieval town and the old shoreline, at the confluence of the rivers Test and Itchen R.P. Royal Pier; D.D Dry Dock; O.T. Ocean Terminal. Owing to the small tidal range and sheltered position there is only one small non-tidal dock (the Inner Dock).

half of all the oceangoing passengers to and from the United Kingdom, especially to and from the United States and South Africa. Thirty of the world's principal shipping companies used to maintain regular passenger services from Southampton to all parts of the world, and from the inception of the Docks in 1842 Southampton has always dealt with the world's largest liners. In this connection it is interesting to note the situation of Southampton relative to the position of Britain described in Chapter 1. It will be seen that steamship services from the northern coasts of Europe, for example, Germany and Holland, proceeding to the Americas or elsewhere are not taken out of their way to any appreciable degree in order to call at Southampton. Hence it is or was the regular calling place of the German liners of the Hamburg-Amerika and Norddeutscher Lloyd, and of the Dutch Holland-America line.

Southampton also ranks fifth in the list of Britain's cargo ports. Practically the whole of the South African deciduous fruit shipped to Britain is received at the Docks as well as about three-quarters of the citrus fruit. There is a large cold store for meat from Australia and New Zealand. Wool, hides, skins, wines, canned fruit, and jams are also received from South Africa. Other imports at Southampton are bananas from the West Indies and West Africa, fresh fruit and vegetables from the Channel Islands and France, timber from the Baltic and Central Europe, grain from Australia, Canada and South America, as well as from English ports, and also coastal cargoes from Scotland and Ireland. The construction of the Esso oil refinery at Fawley in 1952 materially altered the composition of the freight traffic; crude petroleum is now by far the most valuable item in the import list, whilst petroleum products—including bunker oil for foreign ships using the port—are prominent in the export list. Other exports include motor cars and practically every variety of manufactured British goods, shipped to all parts of the world. Southampton's geographical position has made it a good centre for the reception and distribution of cargo of all kinds, especially perishable and express goods. Within 160 kilometres (a hundred miles) radius there is a population of 16 million, an area embracing London (which is reached in under two hours by passenger train and in three hours by freight train), the industrial Midlands, etc., all linked to Southampton by regular rail and road services giving rapid and economic transport and distribution.

Although the bulk of the general cargo traffic is dealt with at the Docks, about one million tons of cargo—much of it to and from the Isle of Wight—is handled annually at the Town Quay, which is owned by the Harbour Board.

For the dry docking and repair of ships there are seven dry docks, ranging in length from 85 to 365 metres (281 to 1200 ft). Overhauls of the largest liners in the world are carried out at the Docks. Thornycroft's shipbuilding yard at Woolston, on the eastern bank of the River Itchen, is noted for the building of naval and commercial vessels.

## Harwich, Dover, Folkestone and Newhaven

It is from these ports that the passenger ferry services to the Continent leave Britain, and to which the now obsolescent term 'packet station' was formerly applied. Harwich serves Holland (the Hook and Flushing) and Denmark (Esbjerg); Dover serves France (Calais and Dunkerque) and Belgium (Ostend); Folkestone serves France (Boulogne), and Newhaven, France (Dieppe); apart from passengers they all have a trade somewhat similar in character and function broadly comparable in each case, though Harwich and Dover far exceed the other two in freight traffic, and also have car ferry services. They all have an import trade made up of perishable foodstuffs such as butter, eggs, fresh meat, poultry, fish, and fruit, as well as manufactured goods in great variety and usually of relatively high value in proportion to their bulk. Exports are mainly of manufactured goods including machinery and motor cars—again valuable goods of relatively small bulk.

## Bristol

Bristol is an excellent example of a port which had initial geographical advantages of which it made full use, but whose advantages were not of the character that could be so readily adapted to supply modern requirements as was the case, for example, with London and Liverpool. Thus Bristol, though remaining a port of no mean significance, has failed to remain in the first rank. There is no evidence of a Roman settlement at Bristol, but the low sandstone hill naturally protected by the marshes of the River Frome on the north and the marshes of the River Avon on the south, the two rivers joining farther to the southwest, supplied an excellent defensible position in the troublous times of Saxon England. Below Bristol the River Avon passes through its famous limestone gorge and empties into the lower part of the estuary of the Severn. The shallow and tortuous course of the upper part of the estuary of the Severn gave Bristol an advantage in competing as an outlet not only for the region to the east of it, but also for the Severn valley.[1] The route eastwards from Bristol was well known because of the Roman spa at Bath which was popular at an early date. Connections with Ireland date from an early period and almost equally fundamental relations with France and Spain are indicated by the early development of the wine trade, wine being an important item in the imports of Bristol then as it is today. Soap making, tanning and wool weaving developed in the thirteenth century, and in 1353 Bristol was made one of the staple towns for the export of wool. The growing importance of the centre was recognised in 1373 when Edward III granted a charter whereby the town and suburbs of Bristol were

1. Despite the construction of the Berkeley Canal, allowing the passage of vessels of 3·3 metres (11 ft) draught, Gloucester fell behind in the competitive race.

made into a separate county. In the meantime the settlement had spread to other sandstone hills in the neighbourhood, and the low ground was utilised for the construction of quays.

The rediscovery of America[1] opened a new field for Bristol; but at first there was severe competition between the port and London. The Merchant Adventurers Society of Bristol received its charter in 1552, but London shot ahead and monopolised much of the new trade. However, the foundation of colonies in Virginia in 1606, and Newfoundland in 1610, saw many men from the west country taking part. The famous Hakluyt himself was Dean of the Cathedral from 1586 onwards. So in the early part of the seventeenth century came the development of the American trade. Though a decree of 1631 had enacted that tobacco should only be imported into London, there was so much smuggling into Bristol that its importation was legalised in 1649. Then came the development of the great Trade Triangle from Bristol just as from Liverpool; Bristol vessels going to West Africa, taking a cargo of slaves to the West Indies and returning to Bristol.

As early as 1612 there were evidently sugar houses in Bristol because there was a protest demanding the removal of one such owing to the danger of fire. The first mention of the establishment of the chocolate industry is in the granting of a patent in 1731 to Walter Churchman of Bristol, whilst in 1753 Joseph Fry was admitted as a freeman of Bristol after five years' residence. But the tortuous course of the Avon practically prohibited the ascent of vessels exceeding 150 tons, and the Merchant Adventurers were compelled in the early part of the eighteenth century to spend considerable sums on additional moorings and the removal of rocks. There was much discussion about the construction of new docks, but nothing definite was done. Bristol largely lost the sugar trade which it has never quite recovered. By the time the docks were constructed in the early part of the nineteenth century, it was too late and prohibitive dues annulled the advantages of the new docks.

With the coming of the railway era Bristol was unfortunate in its close relationship with the network of 2.1-metre (7-ft) gauge lines of the old Great Western Railway. These held back the trade of the city especially in connection with the trade of the Midlands; the change of gauge rendered necessary the handling of goods at Gloucester, putting up transport costs and resulting in the diversion of the traffic to Liverpool. It might be thought that the situation of Bristol so close to the Bristol coalfield would have been a tremendous advantage; but there was never any measure of agreement between the coal-owners and workers and the city authorities in Bristol. Indeed, in 1727, a bill was passed which permitted the setting up of toll gates and taxation on every ton of coal entering Bristol for consumption.

But Bristol occupies an essentially valuable position in the west of England, and the obvious though bold move was the construction of

1. It was John Cabot, a naturalised Venetian of Genoese birth, who had settled in Bristol as a merchant, who really rediscovered the North American continent by landing on Cape Breton Island in 1496.

modern deep-water docks at the mouth of the Avon. This was undertaken both to the north of the Avon at Avonmouth in 1877 and to the south at Portishead in 1879, but whilst Avonmouth went ahead, Portishead became

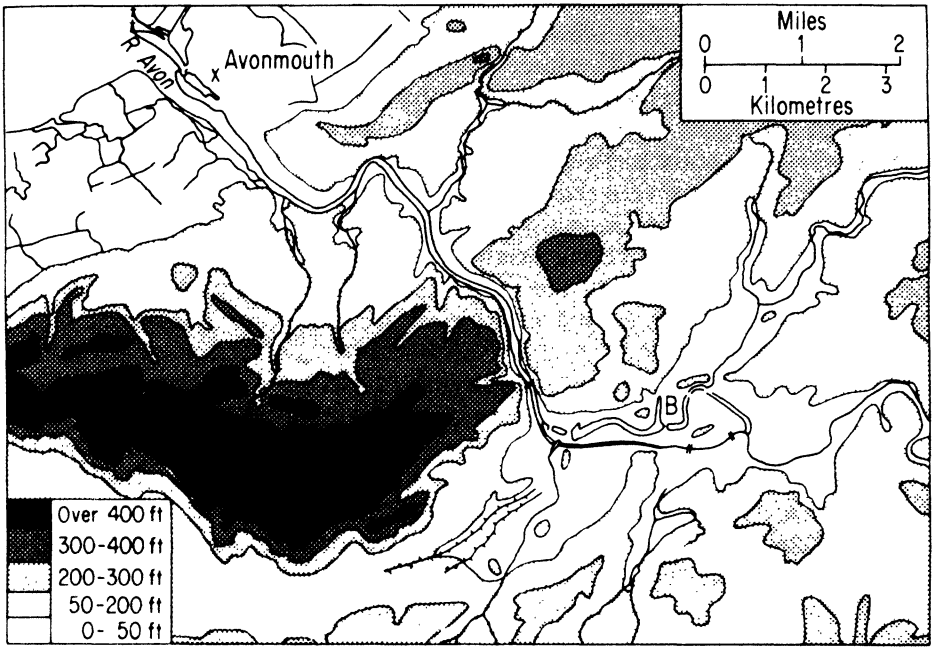



FIG. 261. The physical setting of the city and port of Bristol (B)

Note the ridge of high ground through which the River Avon cuts in the famous Avon gorge *between* Bristol and the sea. This has effectually prevented Bristol from becoming a modern deep-water port, hence the growth of the *outport* Avonmouth

almost disused, except for coal and fuel oil to supply the power stations, and phosphates for a dockside fertiliser factory. One disadvantage of Avonmouth is the enormous rise and fall of the tide, so that vessels have to wait for high tide before they can leave the docks. But facilities have been provided particularly for petroleum storage, the cold storage of butter and meat, the handling, storage, and milling of grain, and the warehousing of tobacco, and a special feature of Avonmouth is the docking there of the West Indian banana vessels. Other imports serve the metallurgical and chemical industries of Severnside—zinc concentrates, aluminium and chemicals. Thus the import trade of the port of Bristol has again shown a marked tendency to increase; but the exports are small, and include paper, chemicals, metals and machinery. The manufactures of the city itself remain those connected with its old West Indian trade—tobacco, chocolate and soap in particular, but the great new industrial complex that is growing up on Severnside is giving a new aspect to the Bristol region. The imagina-

tive proposal for a completely new port—to be called Portbury[1]—has not met with Government approval.

## Glasgow

The city of Glasgow is situated on the River Clyde 35 kilometres (twenty-two miles) from the sea. The port is in reality the result of efforts made by citizens of Glasgow to overcome geographical disadvantages. Less than 200 years ago the River Clyde below Glasgow was a spreading and shallow stream of shoals and sandbanks, fordable at many points as far down the river as 19 kilometres (twelve miles) from Glasgow Bridge. Only about 100 years ago the river was only navigable by small craft drawing not more than about two metres (six or seven feet) of water. As early as 1668 the town council decided to construct their own port by buying a piece of land 5.25 hectares (13 acres) in extent at a point 29 kilometres (eighteen miles) down the river on its left bank. The construction of the town and harbour at New Port was undertaken, the name being changed subsequently to Port Glasgow. Here, in 1812, was built the first dry dock in Scotland. But Port Glasgow was too far away, and already towards the latter part of the eighteenth century efforts had been made to confine the water to the centre of the channel and so to increase the effect of scouring. In 1824 the first steam dredger was brought into operation, and since that date there has been a systematic improvement of the river carried on almost continuously by dredging—as well as the cutting away of the Elderslie rock which presented a serious obstacle for many years. Thus there is now a channel of about 8 metres (26 ft) in depth at low water which, added to a tidal rise of 3.3 to 3.6 metres (11 to 12 ft), makes the port accessible for steamers of the largest trading class. Docks have been constructed and the port is now well equipped.

The expenditure on the improvement of the River Clyde below Glasgow was warranted by the development of the hinterland. The occurrence of coal and iron close together in the immediate vicinity of Glasgow converted it into the centre of a great manufacturing region. The fact that the bed of the river below Glasgow was filled by easily dredged material and mostly soft rocks rendered possible also that extension in width which has enabled the great shipbuilding yards along the Clyde to continue in operation as the size of vessels built there has increased. Then there is, further, the fact that Glasgow shares with Liverpool the advantage of facing the New World. It is true that the North American and West Indian trade began as a smuggling trade before the union of the English and Scottish Parliaments, but after the Act of Union it so flourished that Glasgow led all its English rivals in the import of tobacco.

Glasgow, unlike most of the ports of Britain, has developed an exporting

1. See F. Walker: 'Economic growth on Avonside', *Trans. Inst. Brit. Geog.*, **37**, 1965, 1-13.

trade that is slightly greater in value than its importing trade. The imports include foodstuffs (large quantities of maize, wheat and butter), tobacco, together with petroleum (which is actually discharged at Finnart on Loch Long and sent by pipeline to the Grangemouth refinery—cf. p. 354) and iron ore (at a special quay on the south side of the river in Glasgow itself, with direct rail connection to the Ravenscraig iron and steel works—cf. p. 401). The most valuable export is one of small bulk—whisky; others are the machinery, transport equipment and manufactured goods produced in Central Scotland.

At the mouth of the Clyde, just below Port Glasgow, is Greenock. As a port it has a peculiar trade pattern, for there is really only one import—sugar, for the local refinery; and one export—ships, launched for foreign owners from its shipyards.

## Ports of Eastern Scotland

With the exception of Leith, the ports on the east coast of Scotland are all more or less specialised, and serve very limited hinterlands. Leith has an import trade similar in many respects to that of Hull, and serves as an inlet for cereals (wheat and maize) and for bacon, butter, cheese, eggs and other continental produce required not only for the Edinburgh district but for the more populous areas that lie further west. Its exports include whisky and manufactured goods, including some of the machinery and textile goods produced in central Scotland that are destined mainly for continental markets.

Grangemouth has an oil refinery and a petrochemical industry, and in consequence crude petroleum dominates its import trade—with timber, fertilisers and wood pulp as other imports. Petroleum products and chemicals are the most important exports, together with iron and steel goods and whisky. It is peculiar amongst oil ports in having an export trade greater in value than its imports, but that is because much of its oil, as noted above, is recorded in Glasgow's import trade.

The little port of Burntisland exists almost solely to import bauxite for its alumina works (cf. p. 476); whilst Methil is moribund, with but a very small inwards traffic in wood pulp and timber and a small export of coal.

On the Tay, Dundee's trade is mainly inwards, and is virtually confined to the import of jute, jute fabrics and flax; while farther north, Aberdeen, apart from its important fishing interests (cf. p. 261) is largely concerned with the import of wood pulp, paper and board for its local paper industries.

## Ports of northeast England

The River Tyne from Newcastle and Gateshead to the North Sea, a distance of 16 kilometres (10 miles), forms what is really one large sheltered port. The river valley is entrenched in the low plateau of the coalfield, but

the rocky floor of the valley lies well below sea-level and has been partly infilled with glacial drift. This drift can be excavated with relative ease and this has permitted a dredging and deepening of the river channel to keep pace with the increasing size of vessels launched from Tyneside shipyards. As a port Tyneside has been proverbially (coals and Newcastle) associated with the export of coal for at least six centuries (see above, Chapter 14); but most of the coal now shipped is for coastwise destinations, particularly Thames-side. The several bridges connecting Newcastle and Gateshead are the lowest on the river; colliers and grain ships ascend higher, passing under the high-level bridges and by the help of swing spans through the low level. The river mouth with Tynemouth to the north and South Shields to the south is sheltered from North Sea storms by extensive stone piers or breakwaters.

The improvement of facilities on the Tyne, however, dates only from the middle of the last century, when Northumberland Dock (1857) on the north bank and Tyne Dock at South Shields on the south bank (1859) were constructed to provide space and staithes for coal shipment; the Albert Edward Dock was added at North Shields in 1884. Between the bridges and the docks the river became lined for seven miles with coal staithes, shipyards and other industrial establishments.

In the modern trade of the Tyne coal plays but a very subsidiary role, though there is some coke export to the Continent. The main imports are foodstuffs (bacon, butter, wheat) and raw materials including iron and non-ferrous ores and timber; but machinery, in the form of ships' engines made abroad, is also important, and petroleum products are unloaded at a terminal on the site of the filled-in Northumberland Dock. Iron ore is unloaded at a riverside quay built in 1953, adjacent to Tyne Dock, and goes in special trains to Consett; the non-ferrous ores include lead concentrates for riverside works that once depended on Pennine ores. Exports partly reflect the nature of the hinterland and partly the importance of the Scandinavian trade. Machinery and ships launched for foreign owners play a large part, and many varieties of manufactured goods including textiles from Lancashire, Yorkshire and the recently developed textile industries in the north-east. Clearly the function that the Tyne is best able to perform is that of a link with Scandinavia; the passenger and freight services to Bergen and Oslo (including roll-on, roll-off car ferries) are concentrated at the Tyne Commission Quay adjacent to Albert Edward Dock.

North of the mouth of the Tyne, the former coal port of Blyth stands at the mouth of the river of the same name. Its staithes are idle and there is little traffic of any kind except some import of pit props.

South of the Tyne is the mouth of the Wear, with the port of Sunderland. Here the physical conditions were different; there is no long glacially deepened channel but a rocky bed of Magnesian Limestone, so that the port and its shipyards are much more closely confined to the shore and the immediate vicinity of the river mouth. Petroleum products are brought in

by coastwise tankers, and some pitwood is still imported, but there are few exports other than ships launched for foreign owners.

On the Tees estuary stands Middlesbrough, created from nothing in the nineteenth century, first in the 1830s as a small coal shipment point at the terminus of the Stockton and Darlington and Port Clarence railways and later (after 1875) as a great importer of iron ore and exporter of iron and steel. The wide open estuary and its often shallow stream have been altered fundamentally by training walls built of iron slag and by land reclamation, with recent facilities for oil and iron ore imports in the huge vessels that now characterise these traffics. The increasing variety of large-scale industry on Tees-side, including the great chemical and manmade fibres plants and now oil refineries, have greatly altered the character of the trade, and in terms of value petroleum and products and chemicals take precedence over iron and manganese ore, whilst chemical exports are more valuable than iron and steel. The availability of these valuable and bulky cargoes attracts regular shipping services from all over the world.

## The South Wales ports

South Wales has the distinction of having seven ports in 112 kilometres (seventy miles) of coastline, and in the heyday of the coal trade at the beginning of the present century all were extremely active. For long the prosperity of South Wales depended in large measure on the export of coal, especially the hard steam coals used for bunkering steamers and for the maintenance of supplies in overseas coaling stations. From the narrow mining valleys to the coast is downhill, so that gravity aided the movement of coal by rail, whilst the convergence of valleys into the Taff and Usk led naturally to the development respectively of Cardiff and Newport at their mouths. Towards the western end of the coalfield the valleys were more separated, so that Aberavon (later Port Talbot) grew at the mouth of the Avon, Briton Ferry at the mouth of the Neath, Swansea at the mouth of the Tawe and Llanelli on the estuary of the Loughor. During the nineteenth century one port after another expanded its dock facilities, as more and more competitive railway lines were built to tap the coal-mining valleys. Cardiff developed an outport, at Penarth, and in the 1890s Barry and its railway came into existence in response to the enormous demand for Rhondda coal. All the ports were equipped with coal hoists for loading coal from railway trucks into ships; and in addition of course the steel, tinplate and non-ferrous metal industries, contributed to both import (ores, etc.) and export traffic.

But the coal export trade (cf. p. 318) has collapsed, apart from some anthracite sent out from Swansea. Cardiff and Newport are but shadows of their former selves, though both still have important iron ore imports, Cardiff for its dockside works and Newport for Ebbw Vale and for the great new steelworks at Llanwern; both import pitwood for the mines, Newport

takes aluminium for the Risca smelter and Cardiff has some coastwise oil traffic; both export iron and steel products. Penarth is closed, and Barry, apart from a little coal export (a mere 406 000 metric tons (400 000 long tons) in 1967 compared with 11.1 million metric tons (11 million long tons) in 1913), is largely concerned with the import of bananas and with coastwise oil traffic. Swansea has an advantage for general trade in that it is nearer the open sea than its two rivals; and it still imports crude petroleum in tankers of up to 20 000 tons for the Llandarcy refinery, and nickel matte and zinc concentrates for its remaining non-ferrous metal works; in addition to anthracite it exports tinplate. Port Talbot is simply a specialised iron ore port, that has recently (1969) extended its facilities to accommodate ore carriers of up to 100 000 tons.

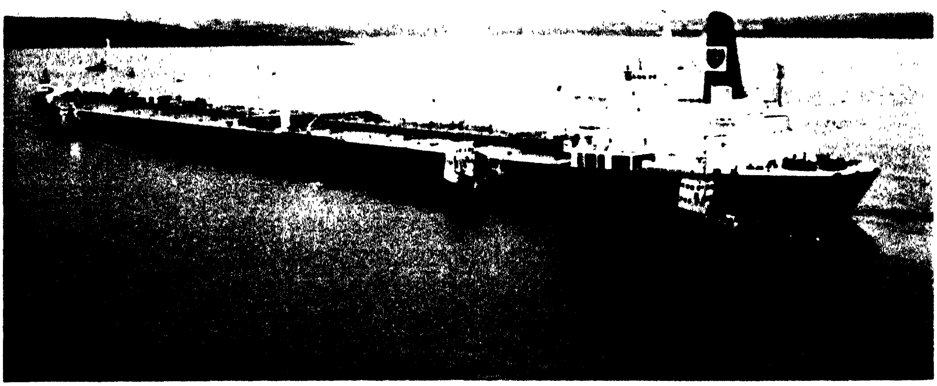


PLATE 32 A 'VLCC' (very large crude carrier) in Milford Haven

The *British Explorer*, 215 000 tons. Looking upstream, the BP terminal at Angle Bay is just above the ship's superstructure; the Esso refinery is above the ship's bow

The outstanding development of recent years in South Wales has been the revival of Milford Haven, with the construction of oil refineries and terminals that can take tankers of 200 000 tons or more. Oil imports in vessels of this size can have a very potent effect on trade statistics. As mentioned above (p. 717), Milford Haven is now the fourth port in the United Kingdom in terms of tonnage of vessels entered and cleared; the value of its trade far exceeds that of any other South Wales port, and its coastwise traffic in petroleum products renders it the third most important port after London and Liverpool for coastwise traffic (if one disregards the 'packet' ports such as Southampton, Isle of Wight and Belfast).

## Minor ports

There remain for consideration numerous small but interesting ports that still play a significant part in the life of the British Isles. The numerous fishing ports of present and past have been considered in Chapter 13 and many of the old fishing ports have a new function in that they cater for pleasure boating and sailing for summer visitors. Then quite a considerable number of ports are significant today for coasting trade, especially for heavy and bulky commodities of which coal is the outstanding example. There is a coastwise despatch of coal from such ports as Ayr, Methil, or Whitehaven, and quite large quantities are received at such centres as Ipswich and Shoreham.

Some ports exist to handle the shipment of a local product—one thinks of Fowey, Par and Charlestown despatching the china clay of Cornwall, whence it goes to Holland and even to America. Building stones such as the granite of Peterhead or road metal are advantageously handled by direct water transport. Many manufacturing centres have their own port facilities —such as the cement ports of the Thames and Medway, where the wharves are normally owned by the industrial concerns and do not handle commodities other than their own. The Medway ports are expanding, and Rochester has a large import of wood pulp for the paper industry.

Dockyards and naval ports such as Rosyth, Chatham, Portsmouth and Devonport (Plymouth) form another group. Still another class are those ports serving Ireland or outlying parts of the British Isles: Stranraer, Larne, Heysham, Preston, Holyhead, Fishguard, Penzance, Weymouth, Wick, Thurso, Stornoway and Oban are a few examples which spring to mind.

A number of minor ports in southeastern England have expanded considerably during the last two decades, taking advantage of their proximity to the Continent with which an increasing proportion of our trade is done (cf. p. 811). Shoreham has specialised since 1951 in the bulk import of French wines and brandies, though its export trade is but small. Felixstowe, reconstructed after the east coast floods of 1953, and profiting by the shelter and deep water of the approach to its neighbour Harwich, has developed a tanker terminal, a roll-on, roll-off terminal and a container base—i.e. all the elements of modern progressive shipping—and has built up a considerable short-sea trade with continental ports such as Antwerp and Rotterdam, with the Mediterranean and with America, offering quick turn-round facilities and freedom from the labour troubles that have plagued London and other large ports. Ipswich, Lowestoft, Yarmouth (transformed from a fishing port into a service station for North Sea gas exploration), King's Lynn and Boston are also far from moribund, and they have an appreciable coastwise traffic as well as foreign connections.

All in all, then, and despite the decadence and demise of some ports, the general impression is one of the extreme richness of the British Isles in natural inlets and harbours that continue to function as gateways for the coastwise and foreign trade of the country.

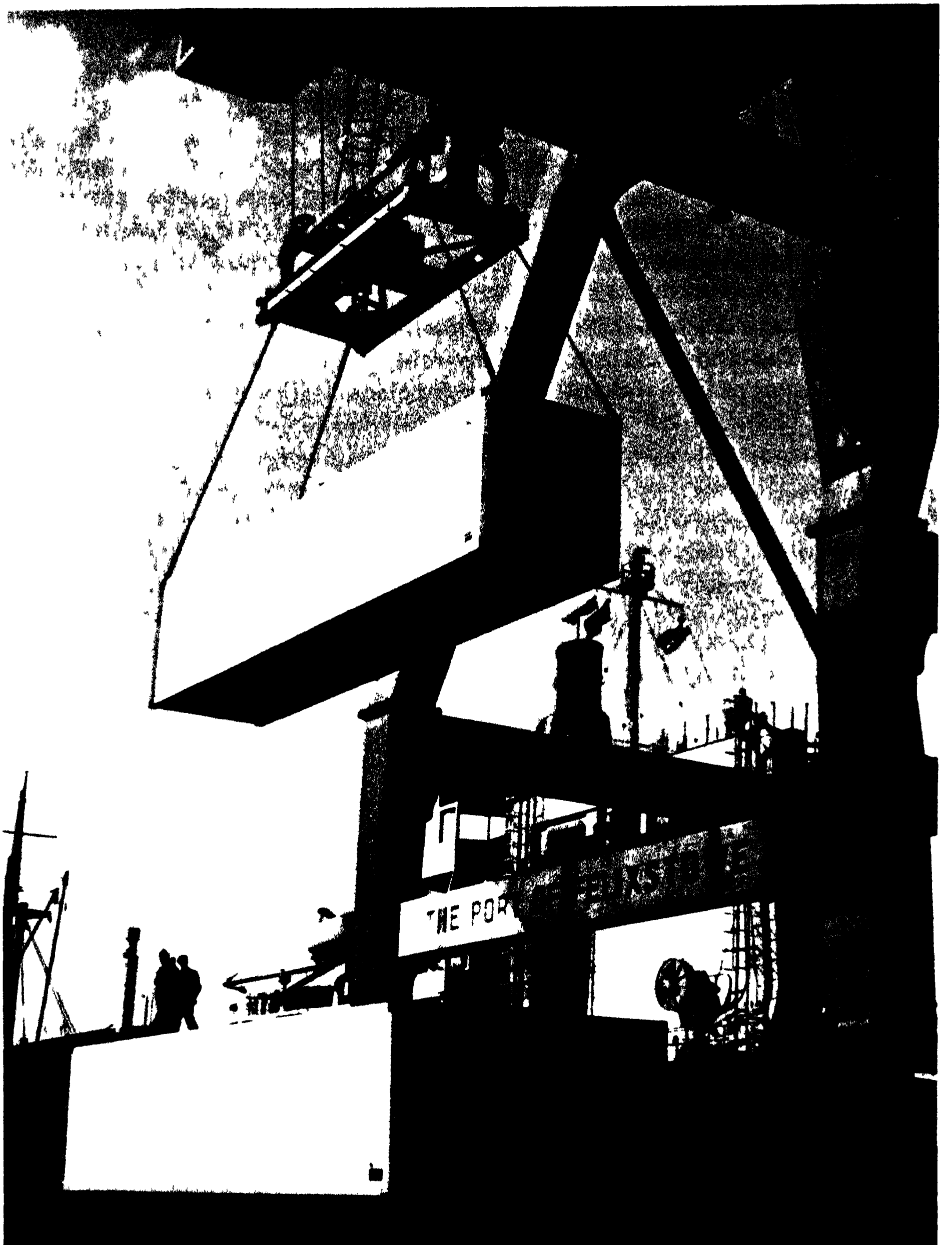


PLATE 33. The container terminal at the port of Felixstowe

## The hinterlands of the ports of Britain

It is not possible to delimit with accuracy the hinterlands of the ports of Britain. Several points may be emphasised. The first is the great extent to which the hinterlands overlap. Thus London serves an ever-increasing area, including not only the greater part of the Midlands of England, but much of the industrial north. Obviously Liverpool embraces within its hinterland the whole of the Lancashire and the Yorkshire industrial regions as well as the industrial regions of the Midlands of England. Hull, whose hinterland was in general coextensive with the Ouse–Trent Basin, now for some purposes extends its tentacles farther, e.g. to east Lancashire. But a factor which it is essential to remember is the specialisation of the modern port for the handling of certain classes of goods. Just to take one small example, Avonmouth has been specially equipped to handle the bananas which are imported in huge quantities into this country. It is true that in this traffic it has rivals in Barry and London, but notwithstanding that bananas are delivered by rail to all parts of Britain from Avonmouth. In this sense, therefore, the whole of Britain may be regarded as lying in the hinterland of Avonmouth. It is only, therefore, in the broadest possible sense that one can attempt any sort of delimitation of British hinterlands.[1]

1. See, however, the very interesting study by J. H. Bird, 'Traffic flows to and from British seaports', *Geography*, **54**, 1969, 284–302.

# 29
# The Irish Republic[1]

In the earlier chapters of this book the British Isles have been considered as a whole. It is impossible in any general study of the geology, geographical evolution or climate of the British region to ignore either the whole or part of the island of Ireland. When, however, one comes to consider the various aspects of economic geography which have been taken up in turn the emphasis has been on the main island of Great Britain or on the political unit of the United Kingdom of Great Britain and Northern Ireland.

The present chapter on the Irish Republic has been included for the sake of completeness, but it should not be regarded as more than the merest introduction to the geography of a very interesting country.

## Historical note

The Irish Republic is a sovereign independent state and its jurisdiction covers twenty-six of the thirty-two counties of Ireland, including the whole of the three historic provinces of Leinster, Munster and Connaught (Connacht), together with three of the counties (Cavan, Monaghan and Donegal), of the former province of Ulster.

After what has become known as the Easter Rebellion of 1916 a Republic was proclaimed and in due course the British parliament recognised its independence. On 6 December 1921 the Treaty was signed and a boundary was demarcated between the Irish Republic and Northern Ireland. From 1921 to 1937 the official name used for the Republic was Saorstat Éireann, or the Irish Free State. Later the name Eire (literally Ireland, since the State does not officially recognise the existence of Northern Ireland) came to be used, to be changed in 1949 to the present official title, the Irish Republic, or Poblacht na h Éireann.

Apart from the fact that there are close commercial ties between the Irish Republic and the United Kingdom in that the large population of Britain forms a natural market for Irish agricultural produce, the Republic is independent in every way of the United Kingdom Government and ceased to be a member of the Commonwealth in 1949. The head of the Irish Republic is the President, and government is by the Dail and Senate.

1. We are deeply grateful to Mr T. W. Freeman for most valuable comments on this chapter and the next.

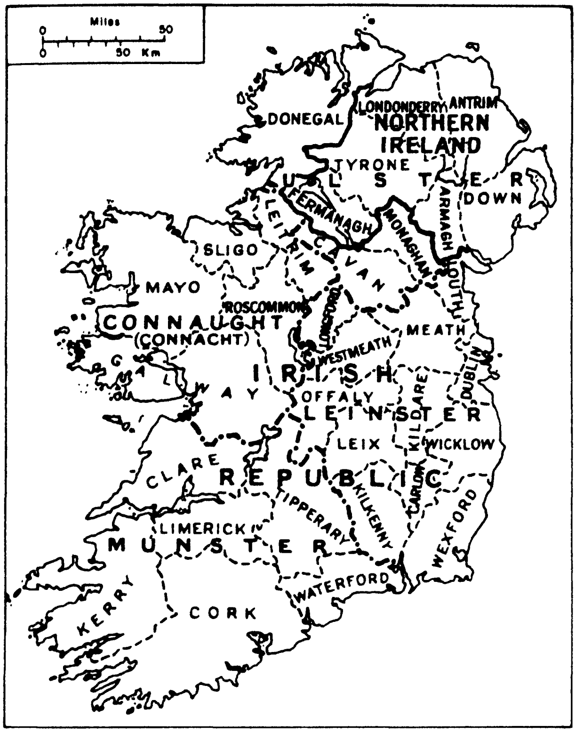



FIG. 262. Political map of Ireland

## Population

The population of the island of Ireland expanded rapidly from about 1770 to the 1840s. This expansion was made possible by the great development in the cultivation of potatoes, which became the staple article of diet of the Irish farmer and farm worker. The failure of successive potato harvests led to the terrible famines of the years 1845–47, in the course of which very large numbers died of starvation, and which gave rise to the great streams of migrants, especially to the United States. Ireland has in fact never recovered from the effects of those famines of over 100 years ago, and in the past century the total population has been reduced by half.

The first actual census of the whole island was taken in 1821 and recorded a population of 6 802 000. This total by 1841 had reached 8 175 000 and by 1845, when the famine struck, was probably approaching 8½ million despite the considerable emigration which had already taken place. This may be contrasted with the population of the Irish Republic and Northern Ireland in 1961 of 4 240 000. It will be noted that the population of Northern Ireland is now steadily increasing due mainly to the vigorous policy of industrialisation in Belfast and neighbourhood. In the Irish Republic, on the other hand, the population continued to decline slowly, though there was a slight in-

crease from 1946–51, to 2 960 593. This was followed by ten years of decline to 1961, with 2 814 703 but an increase to 2 884 002 by 1966.

In contrast to the present population in the Irish Republic of less than three million the number of emigrants has been truly remarkable. There was no count of the immigrants at the ports of entry before 1851, but it was calculated that there were already nearly one million in the United States, three-quarters of a million in Britain, and one-quarter of a million in Canada. In the year 1847 alone more than a quarter of a million Irish refugees landed at Liverpool, the majority of whom settled in the growing factory towns of the north of England, where their descendants remain to this day.

In the ten years 1851–61 another 1¼ million emigrants left the ports of the British Isles, mostly destined for the United States and Canada. So migration went on and although it steadily slowed down, especially after 1891, over two million have left the island in the past fifty years. Since 1930 the main migration from Ireland has been to Great Britain. It is of course difficult to give anything approaching exact figures, but it has been estimated that people of Irish descent living in America and elsewhere total something like 16 million or more than five times the total number remaining in the Irish Republic.

Considerable parts of Ireland are actually uninhabited—the mountains and the lowland bogs—so that if one excludes these uninhabited areas the population density over the settled parts presents a very different appearance from population density calculated over the whole. At the census of 1961 average rural density in the whole Republic was about 23 per square kilometre (60 per square mile), but excluding the uninhabited areas over half the country had an average density of between 20 and 39 per square kilometre (50 and 100 per square mile), much of the remaining half between 39 and 77 per square kilometre (100 and 200 per square mile) whilst the inhabited fringes of the remote west, the so-called congested districts, supported between 77 and 115 per square kilometre (200 and 300 persons per square mile), in some cases actually over 155 per square kilometre (400 per square mile) of cultivated land.

Over the greater part of the Irish Republic the rural population exceeds 75 per cent of the whole. The settlement is scattered, villages are rare. Although the word 'town' is used to cover nucleated settlements, many of the so-called towns boast less than 200 people and indeed many places with between 800 and 1500 people are, in social and economic functions, towns. The needs of farmers are served especially, however, by those market towns which have between 1500 and 5000 people. There are nearly seventy of this size in the Irish Republic, and a much smaller number of larger ones. In the Irish Republic Dublin with its port, Dun Laoghaire, boasts over 700 000 people, and stands in a class by itself. The expansion has been particularly marked since 1946. If one includes the surrounding residential areas Cork exceeds 130 000, Limerick has now nearly 60 000 and Waterford has almost

30 000. These four towns, however, have exhibited the phenomenon of urbanisation which is almost universal. Over the period 1891–1961 the four together had increased by 43 per cent, and at the 1961 census contained more than one-quarter of the total population. By way of contrast the purely rural areas, including settlements of less than 1500, had decreased by 29 per cent over the same period, and from embracing three-quarters of the total now have only a little over 60 per cent.

It will be clear that apart from the four towns specially mentioned the Republic remains essentially rural and agricultural.

## Agricultural regions

The agricultural regions of Ireland show a close coincidence with those determined on a basis of geological structure and relief, although the old familiar statement that Ireland consists of a central plain—more strictly a low plateau so plastered with glacial deposits as to have everywhere impeded and irregular drainage—with an interrupted rim of mountains and hills remains broadly true.

One must remember, however, that the rim is very irregular in character and consists really of a number of isolated hill masses, while the central plain itself is interrupted especially towards the southwestern margins by numerous ranges or isolated hill masses. The central plain further reaches the coast in a number of points.

The physical regions which may also be discussed as agricultural regions are shown on Fig. 263.[1] This may be compared with the next figure, showing the types of farming in Ireland.

The regions may now be taken in order.

(*a*) The mountains and uplands of the southeast (Wicklow and Wexford).
(*b*) The parallel ranges and valleys of the southwest.
(*c*) The mountain masses of the northwest (Connemara, Mayo and Donegal).
(*d*) The uplands of the northeast which are a continuation of the uplands of Northern Ireland.
(*e*) The central lowland and its fringing areas.

## The mountains and uplands of the southeast or the Leinster Chain

This well-marked area was doubtless once continuous with north and central Wales, with which the southeastern part in particular is structurally similar; the northern part (actually forming the Wicklow Mountains) consists in the main of the largest granitic intrusion in the British Isles. There is thus geographically a twofold division of the whole area:

1. For a more recent interpretation see D. A. Gillmor: 'The agricultural regions of the Republic of Ireland', *Irish Geography*, 5, 1967, 245–61.

(*a*) The *Wicklow Mountains*, which narrow southwards on the other side of the gorge of the River Slaney to Mt Leinster and the Blackstairs Mountains.
(*b*) The *low plateau* or *uplands of County Wexford*, which extend northwards, narrowing to form the coastal belt of the eastern part of Wicklow.

The whole region is remarkable in the first instance because of the completeness of the barrier which it offers between the southeastern coast of Ireland and the central lowlands. The whole region may, alternatively, be called the Leinster Chain, and to this day no railway crosses this barrier. Further, the main mass of the Wicklow Mountains is uncrossed even now by a motor road.

### The Wicklow Mountains

The Wicklow Mountains, reaching northwards almost to the outskirts of Dublin, are remarkable not only for the barrier which they offer, but also

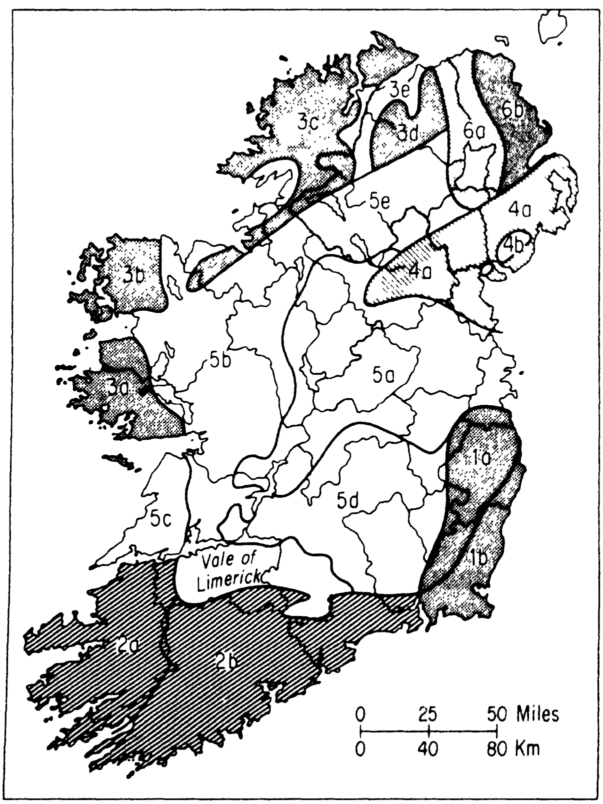



Fig. 263. The agricultural regions of Ireland
For explanation, see text.

for the contrast between the wide open moorlands of the higher parts, and the deep secluded valleys of the east. The moorlands reach elevations of over 925 metres (about 3030 ft) in Lugnaquillia, the highest summit in eastern Ireland, while a very large number of the rounded summits of the moorlands reach over 610 metres (2000 ft). The breadth of the Wicklow Mountains varies between 16 and 25 kilometres (ten and fifteen miles). The streams which rise in the moors flow in comparatively broad shallow valleys until they reach the areas of slope which flank the chain itself. Here the descent is continued in deep gorge-like valleys which are frequently richly wooded, and these glens have long been famous for their scenic beauties, well-known examples being the Glendalough valley and the Avoca Vale.

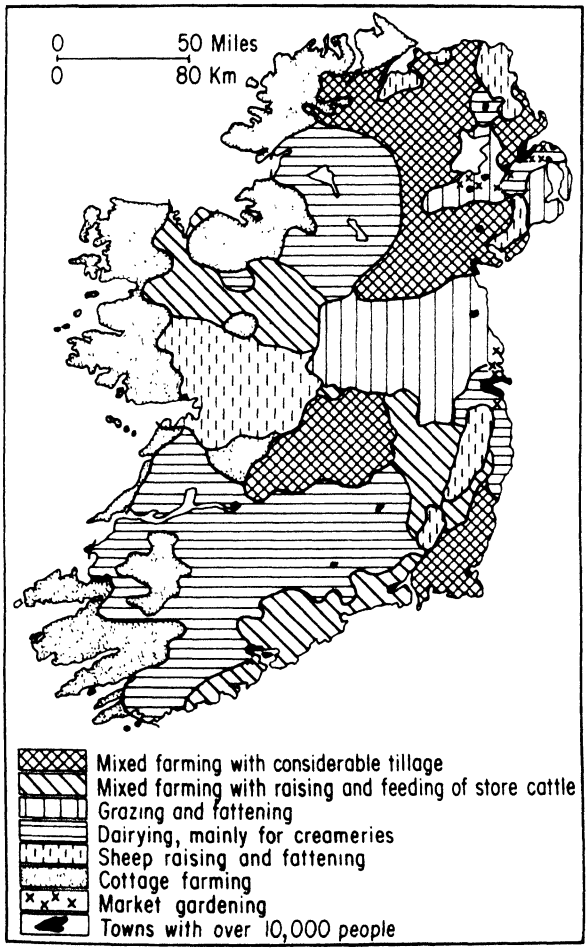



FIG. 264. Types of farming in Ireland

*Simplified from T. W. Freeman, Ireland, by permission of the author and Messrs Methuen & Co. Ltd*

It is towards the south that the granite ridge is breached by the River Slaney which passes through a deep gorge guarded by the village or small town of Clonegall. To the southwest of the Slaney gorge the Mt Leinster–Blackstairs range has two nuclei each over 730 metres (2400 ft) in height separated by the Scullogue Gap, a defile which has been used in the past by bold chieftains desiring to travel from Enniscorthy, the tidal head of navigation on the River Slaney, to Kilkenny, the next important centre towards the heart of the country. Because of their elevation the Wicklow Mountains experience a heavy annual rainfall, in spite of their situation on the eastern or drier side of Ireland. But in the secluded glens of the east the rainfall is less, and these glens benefit from the high summer temperatures, the July mean being over 15.5°C (60°F), although it is of course lower than in the corresponding regions in eastern England. These eastern glens, being sheltered from the rainy westerly or southwesterly winds, form one of the few areas in Ireland where considerable extents of woodland have been preserved. Wicklow timber was valued in very early times and a process of systematic deforestation began when the Anglo-Normans of the Pale exported the oak and other woods in large quantities. The suitability of the area for afforestation has been recognised in recent years, and considerable areas have been planted. Agriculturally, the main importance of the area is for the sheep pastures which are afforded by the open moorland, but there are restricted though good areas of cultivation in the secluded vales. Thus the sheep farming of the centre gives place to rearing of store cattle on the margin, or to dairy farming where accessible from Dublin and Bray. For long the tribes of the Leinster Chain maintained a sturdy independence. They had their strongholds at the entrances to the narrow valleys which led to the high moorlands, and to which they could retreat if need should arise. Yet from the Bronze Age onwards the mineral wealth of Wicklow caused traders to be attracted to the district, particularly for gold and copper, ores of which occurred on the eastern side of the Highlands, and which became known to the people of all Ireland.

## The Wexford uplands and plains

To the south and east of the Wicklow Mountains there lies an area almost completely cut off from the remainder of Ireland. It occupies the greater part of Wexford and narrows northwards to form a small plain between the Wicklow Mountains and the sea. It is an area of old rocks which weather to form a moderately good soil. Over large areas glacial deposits are absent. Where they occur they consist mainly of shallow sands, marls, and clays which help to produce soil of excellent quality. As elsewhere in Ireland mixed farming is the rule: here more crops than usual. This corner of Ireland has relatively dry warm summers, and the climatic conditions combined with the soil have produced here what is *par excellence* the barley–wheat–oats region of the country, in which potatoes and pigs are also im-

portant. The country is undulating, and generally well drained so that bogs are almost non-existent. Although naturally not nearly so predominantly arable as the eastern parts of England, nearly a third of Wexford is recorded in the returns as arable. Despite this agriculturally favourable aspect of the country its isolation by nature is apparent from the numerous simple little


FIG. 265. The distribution of farms of different sizes in Ireland

*(From T. W. Freeman, Ireland, by permission of the author and Messrs Methuen & Co. Ltd*

whitewashed cabins which are so reminiscent of the remote west. Northwards, where the plain narrows to the strip between the Wicklow Mountains and the Wicklow coast, is an interesting area sometimes referred to as the 'Garden of Ireland'. It is pleasant, comparatively well-wooded 'close' country of very English aspect, free from bogs, and supporting numbers of dairy cattle as well as sheep. It is from this area that the valleys penetrate into the mountains. It might be thought that this pleasant coastland would have been subject to invasions from the east, that is, from the other side of the Irish Sea, but actually, throughout historic time it was dominated by

the tribesmen of the Wicklow Hills. The presence of such a stronghold of hill people near Dublin was for very long a source of danger and difficulty to those who sought to establish authority over the whole of Ireland from its natural centre at Dublin. Thus as late as 1800 it was necessary to construct a military road to traverse the high moorlands from Dublin to the Aughrim Valley. Even today the one main road and railway which connects Dublin with the southeast of Ireland runs along the narrow coastland through the picturesque watering place of Bray; whilst the famous Round Tower of Glendalough remains there as a permanent reminder of the long-held strongholds of early Christianity in the secluded valleys of the mountains.

## The parallel ranges and valleys of the southwest

Southwestern Ireland is built up of a series of long, comparatively barren ridges of Old Red Sandstone trending roughly from eastnortheast to westsouthwest, separated by damp, fairly fertile valleys of Carboniferous Limestone covered by superficial deposits. The country thus owes its structure and relief to the Armorican series of earth movements. Whilst the hill ridges with their rough sheep pastures and the valleys with their damp cattle pastures and famous dairy herds form one natural twofold division of this part of Ireland, there is another which should be considered. There is the west, corresponding roughly with County Kerry, so cut off from the remainder of Ireland by ridges of mountains that it has been described, not ineptly, as a region under the title of the Munster Barrier. It is here that the wild mountains of Old Red Sandstone reach their greatest elevation, and where the intervening valleys pass seawards into long narrow arms of the sea known as rias,[1] in contradistinction to fiords of different character and origin. To the east the mountains are less rugged and less wild, the valleys broader and of greater importance to the country as a whole. Here is part of the greatest dairying region in Ireland, with such important centres as Cork and Waterford, as well as an area devoted rather to feeding of cattle. Actually, dairying and feeding are commonly found on the same farm.

### The mountains of County Kerry and West Cork

This region really stretches from the wide estuary of the Shannon on the north to Bantry Bay on the south. The high mountain rampart which separates it from the remainder of southern Ireland on the east and southeast is lofty, bare or bog-encumbered country, intervening between the long valleys opening westwards to the Atlantic and the wide basins of the Lee and

1. A ria becomes progressively deeper seawards; there is not the submerged lip so commonly found in the case of fiords and due to a morainic ridge. It is not without significance that Bantry Bay, like Milford Haven in South Wales, which is also a ria, should have been selected as the site of a great modern oil terminal to take vessels of 300 000 tons.

Blackwater, rivers draining eastwards and then south to the sea. Amongst the mountains of Kerry are the famous Macgillycuddy's Reeks, with the highest mountain in Ireland. In these peninsulas of the west the mountains occupy most of the country and support on their rough pastures numerous sheep, whilst the farms include many of 12 to 20 hectares (30–50 acres) but

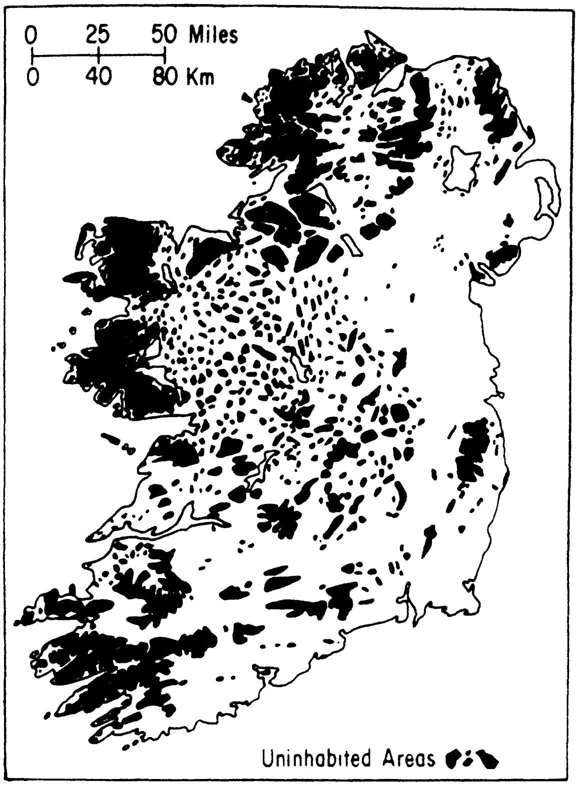



Fig. 266. The uninhabited areas of Ireland

*From T. W. Freeman, Ireland, by permission of the author and Messrs Methuen & Co. Ltd*

also numerous small holdings—cottage farming comparable with the crofting of Scotland. The whole region is essentially a pastoral one, for cultivation is rare in Kerry, and even the fertile tracts are generally used for cattle rearing owing mainly to conditions of climate. Western Kerry has the heaviest annual rainfall for the whole of Ireland, the total in places actually exceeding 2500 millimetres (100 in) per annum. At the same time the climate is remarkably mild, especially in the winter months, when an average of over 6.6°C (44°F) is maintained, and a mean January temperature of 7·7°C (46°F) is recorded in parts of western Kerry, being the highest figure for any area in the British Isles. The heavy moisture and excessive mildness of the climate is reflected in certain local features of the vegetation, rich in

ferns and mosses, and even including plants native to the western Mediterranean. Although to the west the force of winds from the Atlantic may prohibit tree growth, over restricted areas in the more sheltered valleys are the famous woods of Kerry, including in particular the strawberry tree (*Arbutus unedo*). Modern roads no longer leave this an isolated tract, and the wild country is much loved by visitors to Killarney. Previously the district was one of great isolation; the farming communities of Kerry have remained detached from the main stream of economic, political and social affairs of Ireland. But much of the area is inhospitable and unsuitable to settlement, and the traditional capital of Munster (Cork) as well as its important towns are situated to the east of the barrier. It was only in times of stress that the people naturally withdrew to their mountain fastnesses in the extreme southwest. Even the Viking invaders, used as they were to the mountainous conditions of Norway, preferred to avoid this western side of Kerry; though they established settlements at Limerick and at Cork there does not seem to be evidence that they attempted a settlement here.

## The parallel valleys of Cork and Waterford

This, the eastern half of the southwestern region, has many of the advantages (such as mildness of climate and moisture to produce fine pastures) of the mountainous regions of Kerry, but is without its disadvantages. The drift-covered limestone lowlands afford some of the finest pasture in Ireland. The country to the south may be matched by that to the north in the famous Golden Vale of Limerick and Tipperary. This has thus become one of the main dairy farming regions of Ireland. Turnips and potatoes are grown in the lowlands, oats are mainly restricted to the southern part in County Cork. Pigs are an important byproduct of the dairying industry. It will be seen that in general the rivers and the river valleys have a trend eastwards, parallel to that of the mountain ridges. In succession from south to north one may notice the course of the Bandon River, the Lee and the Blackwater, but the region is not as isolated from the central lowland of Ireland as might be expected, because of the transverse valleys which interrupt the east–west mountains. An excellent example is that followed by the railway from Mallow to Cork, affording an easy line of movement between Cork and Limerick. In earlier days these routes were not as easy nor as practical as they are today; thus, although Limerick and Cork were settled by allied bands of Northmen, contact was closer between Cork and Waterford than between Cork and Limerick although the settlers in the two latter areas were originally more closely allied. Intercommunication between the farms in the valleys and the main centres has been an essential factor in the development of the cooperative dairy farming. In many parts 90 per cent of the milk produced on the farms, notably in the county of Limerick, is dealt with in cooperative dairies, an indication of the high pitch of efficiency to which the industry has there been taken. In the east the important and fertile valley of the Suir, Nore and Barrow focus on Waterford.

## The mountains of the northwest

These mountains are built up of the same ancient metamorphic rocks as those which make up the Highlands of Scotland. The mountain rampart is exposed to the full force of the relentless waves of the Atlantic Ocean. There are innumerable rocky headlands and deep inlets overshadowed by barren rocky heights. In two places structural weaknesses have allowed the sea to penetrate the mountain rampart as far as the fringes of the central lowlands. These two inlets are Clew Bay and the wider Donegal–Sligo Bay, and they have the effect of separating the mountain rampart into three parts: the mountains of Connemara in the south, the mountains of Mayo in the centre, and the mountains of Donegal or Tirconnail in the north. The first two are often linked together as the Connacht Highlands, whilst the latter is the northwestern Highland properly speaking. The whole of this part of Ireland is exposed to the full force of the rain-bearing winds from the Atlantic Ocean. Large areas are so bleak as to be uninhabitable and tree growth is impossible. Extensive areas of the higher land were swept bare of soil during the great Ice Age, whilst between the barren mountains there are huge glaciated surfaces, waterlogged and occupied by vast boggy moorlands which are again practically uninhabited. The population exists crowded together in the valleys and especially along the coast, and like the crofters of Scotland, the people live by carrying on subsistence farming. Sheep live on the better-drained slopes and furnish the wool for the famous Irish and Donegal tweeds. Potatoes are often almost the only crop possible, and there is frequently clear evidence of conscious and unconscious attempt of man and animal alike to seek shelter on the lee side of hills away from the full force of the Atlantic winds. In such situations are the little homesteads; here alone will trees grow.

### The mountains of Connemara

The region corresponds with the western third of Galway and the southwestern corner of County Mayo. Running northwards from the town of Galway is the Limestone belt which is described below as part of the fringe of the Central Lowlands. Westwards the junction between the often bare limestone surfaces and the ancient rocks of the highlands is usually quite sharp—so sharp that the line can often easily be drawn on a map. Actually along the junction there are frequently prosperous farms in wooded sheltered hollows; but away from this margin stretch great expanses of almost uninhabited moorland. Shallow treacherous lakes occupy every hollow, and are in turn fringed by bogs; whilst between the lakes are extensive stretches of bare glaciated rock surface. Rounded mountain masses often practically bare of soil rise in lonely grandeur from the lake-studded lowlands. Their more fertile slopes may be covered by a moorland in which bracken and heather are important. Some of the scenic effects, such as the

view of the Twelve Bens or Pins of Connemara seen from the south, are both majestic and awe-inspiring. Where the glaciated mountains reach the coast, the scenery again is often very fine, as in the fiord known as Killary Harbour. 'Much of the sparse settlement in this region is along the coast,

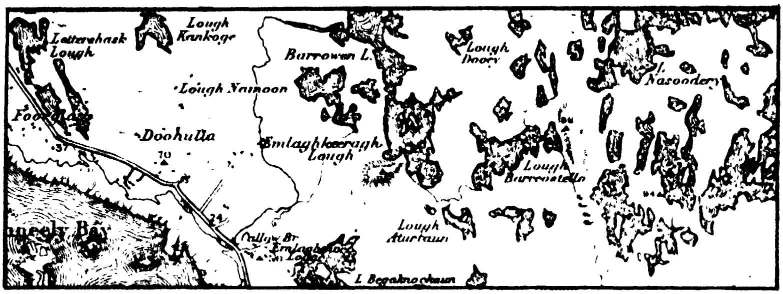



FIG. 267. Part of the lake-studded lowland of Connemara

Note the restriction of settlements to the coast Scale, 1 inch to 1 mile Reproduced from the Ordnance Survey map by permission

where fishing may be combined with subsistence farming, and where seaward drainage helps to improve the natural conditions. Little whitewashed single-storied thatched cabins lie scattered along the coast wherever a few fields sufficiently free from boulders may be secured. Frequently the little farm is situated on a slope with rough sheep pastures above and where hay, oats and potatoes may be grown on a narrow strip of land between the farm and the sea. A few small black cattle, an occasional pig and a few poultry form the rest of the livestock. Such is the character of the country around Clifden.'[1] It should be noticed that in this far west even good pasture is scarce.

## The mountains of Mayo

These are broadly similar to the mountains of Connemara and Joyce's Country to the south of Clew Bay. The width of the mountains of Mayo from north to south—that is from Clew Bay to the north—is roughly 50 kilometres (thirty miles), but only one road forces its way across them in this distance. The 147 square kilometres (fifty-seven square miles) which make up Achill Island, the largest island off the Irish coast, consist almost entirely of wild moorland with only very occasional patches of cultivation. No districts in Ireland are more isolated from the main currents of national life than are these desolate tracts of western Galway and western Mayo. It is there, not unnaturally, that we find today the descendants of the earliest inhabitants of the island. Through the ages the sturdy hillsmen remained in defiance of foreign overlords coming there from across the plains to the east. To this day dark-skinned descendants of Neolithic man

1. L. D. Stamp, *An Agricultural Atlas of Ireland*, p. 60.

are to be found in the hill country of Galway and Mayo. This is, indeed, one of the remotest fringes of Europe.[1] Railways reach Ballina, in north Mayo, Westport or Clew Bay, and the City of Galway. From all these places bus services run to places in the extreme west and Coras Iompair Eireann, which organises all public transport, also provides lorry and van services.

## Donegal or Tirconnail[2]

In the windswept land of Conall the barrenness and rugged character of the Irish highlands reach their maximum, but though the coast is usually very broken and rockbound the main mountain masses terminate abruptly before reaching the sea, there being usually a low, though narrow, coastal plain which makes possible the existence of a larger population in Donegal than in the bleaker, but less majestic, mountain country of Mayo and Galway. This is readily apparent in the maps showing the distribution of potatoes in the Irish Republic (Fig. 270), there being obviously more land under cultivation on the fringe of the Donegal mountains than in either of the preceding areas. This is true, for example, of the coastal fringe of the peninsula of Inishowen.[3] The climate is, of course, characterised by the prevalence of strong westerly and southwesterly winds, bringing a heavy annual rainfall, and by a mildness of temperature at all seasons. This is important. The absence of frost is marked particularly, and it is thus possible for the small cattle breeder of Donegal to allow his animals to remain in the fields even during the winter, at least in most years. The cattle thrive on the verdant pastures which are possible in many of the valleys, whilst on the hillsides are numerous sheep. Woodland is naturally absent in Donegal except on the sheltered, usually the eastern, sides of the hill slopes. On the east the mountainous massif of Donegal abuts against the broad, comparatively fertile, corridor which is formed in the main by the valley of the Foyle River and, by analogy with Scotland, may be called the Foyle Strath. Along it there now runs the boundary between the Irish Republic and Northern Ireland. The rugged mountain scenery of the northwestern massif appears again to the east of the Foyle Strath in the Sperrin Mountains of Northern Ireland. The lowland basin of the Foyle has long been the focus of human activities. Strabane in Northern Ireland is one of the most important road centres of the area, and here the chief tributary of the River Foyle, the River Finn, joins the main stream. The east side of Donegal is far more fertile than the west, and a light railway formerly ran to the towns of Donegal and Killybegs (closed in 1959). The natural centre for the Foyle basin is Londonderry, in Northern Ireland, but the customs frontier is close to the town.

1. E. Estyn Evans, 'The Atlantic ends of Europe', *Advmt Sci.*, 15, 1 58, 54–64.
2. Tir Chonaill = the Land of Conall.
3. Inishowen = island of Owen.

## The uplands of the northeast

Lying in the counties of Cavan, Monaghan and Louth is the continuation of the rolling country more fully described under Northern Ireland. Though the old rocks are largely masked by glacial deposits—this is part of the great drumlin belt—the drainage here is much better than in the plains of central Ireland to the south; bogs become infrequent or have been drained, but as in the neighbouring parts of Northern Ireland, there are rich pastures, more accessible than those amongst the bogs and so giving rise to a country where dairy cattle are important, and where there is an extensive cultivation of potatoes, as well as of oats, and in the drier east some barley and wheat. Pigs are numerous as a byproduct of the dairy farming industry; sheep are numerous on the drier pastures.

## The central lowlands

Now that the fringing highland masses of the Irish Republic have been described, there remains a great central region which is on the whole a lowland. It seems best to consider it as made up of four parts:

(*a*) The central lowland which is mainly 60–120 metres (200–400 ft) above sea level with only low hills.
(*b*) The western fringe, where well-drained areas of glacial deposits and bare limestone tracts make a varied landscape.
(*c*) The limestone uplands of County Clare.
(*d*) The southern area, where great tongues of lowland are separated by hill masses, and where the fertile river valleys merge insensibly into the similar valleys of southwestern Ireland.

### The central lowland

On the ordinary solid geological map this tract appears as a broad sweep of Carboniferous Limestone, which extends also to the western fringe and far to the south. Over much of the central lowland, however, the limestone is rarely seen. It is masked by a spread of glacial and later deposits. There are wide areas of waterlogged boulder clay interrupted by infertile glacial sands and occasionally by loam. On a low-lying area of such a character, drainage is naturally bad. It is rendered worse by the presence of the limestone below, for water tends to pass through fissures in the limestone rather than across the surface by regular watercourses. The curse of the central lowland is bad drainage and consequent formation of huge bogs. Away from the bogs it is a land of wet pastures where little cultivation is possible. The whole may indeed well be described as the beef- and bog-land of Ireland. Some of the larger bogs may be 8 or even 16 kilometres (five or ten miles) across; and it is not infrequently a journey of some distance from a main road to an isolated farm. With such difficulties of communication it is obvious that dairy

farming is practically impossible. The regular collection of the milk for a central creamery would be out of the question. If dairy cattle are kept, as they are in small numbers, butter is made at the individual farms. On the other hand the damp pastures are, of course, excellent for cattle. Hence, as a map showing the distribution of beef cattle would indicate, there is an

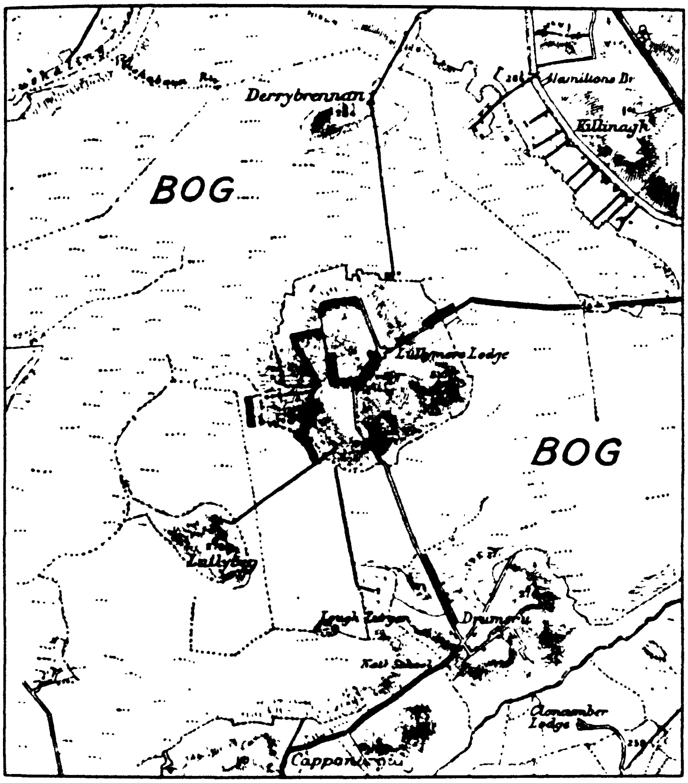



FIG. 268. Part of the central lowland of Ireland, in the region of the great bogs, showing 'islands' of well-drained sands, very difficult of access, in waterlogged bogland. It is not surprising that Lullymore on this map has been abandoned as a farm
Scale, 1 inch to 1 mile. Reproduced from the Ordnance Survey map by permission

immense concentration of the stock-rearing industry on the central lowland. Especially in the immediate hinterland of Dublin are there large numbers ready for export to Britain. There is little cultivation of land, but the importance of potatoes relative to oats indicates the greater adaptability of potatoes as a food crop. In the south turnips become important—obviously grown as a cattle food.

The central lowland reaches the Irish Sea in the lowland stretch between the Wicklow Mountains on the south and the low hills of County Louth on the north. Here is the obvious gateway to the heart of Ireland, and the

natural position for the capital. Notwithstanding this fact, communication across the central lowland is not easy. It has been facilitated, however, by the presence of ridges of glacial origin and the old roadways carefully avoided the peat bogs by traversing the well-drained glacial deposits including, in some places, sandy ridges called eskers, some of which run conveniently from east to west. Even when the land of the great bogs has been traversed, there is the difficulty of crossing the wide marshy valley of the Shannon or the considerable bog-fringed lakes through which the river passes. Thus, naturally, the Shannon formed the boundary between the ancient kingdoms of Connacht on the west and Leinster on the east; whilst the position of the town of Athlone, where a crossing of the Shannon is rendered possible, is doubly emphasised by its presentday importance as a railway junction and as a road centre. The esker ridges consist of roughly stratified sands and gravels, and are normally grass-covered. They probably mark the courses of subglacial streams which were developed towards the close of the Ice Age. On some of the eskers and comparable mounds of glacial origin in the north and south of the main part of the central lowland sheep are numerous. The importance of these glacial ridges is heightened during the heavy rains of autumn and winter when the subterranean waters, such a common feature of limestone country, rise in the neighbouring hollows, locally known as 'turloughs', and convert them into shallow lakes.

To the southwest of Dublin is the Kildare country—especially famous for its breeding of race-horses and Irish hunters. Even the wettest parts of the central lowland—for example, the Shannon Basin—are actually at a considerable height above sea-level, and it is, of course, this fact which has made possible the development of the Shannon hydroelectric power scheme. Consequently, towards the eastern section of the central lowland, where drainage to the sea is better, there are tracts much more favourable for the development of agriculture. Here the seasonal temperatures are the most extreme for Ireland, though even so the variation between average January and July mean temperatures is only about 11 degrees C (20 degrees F). The effect of prevailing westerly or southwesterly winds on vegetation is much less marked, and tree growth tends to be more abundant. On the other hand cold easterly and northeasterly winds in winter are able to penetrate a considerable distance into the central lowlands. Along the coastal fringe, the cultivation of barley, wheat and potatoes is seen to assume a greater importance. It is a matter of the greatest significance that this better-drained land should be on the eastern side.

The central lowland has been in each epoch of invasion the home of the foreigner who has entered from the Irish Sea. The Vikings established their settlement in Dublin, and the port became the stronghold of the stranger just as it has been at many succeeding dates. The Anglo-Normans established in Dublin their outpost from England and their headquarters for the conquest of the wide central lowland. Not unreasonably the holder of the port of Dublin would feel confident ultimately of establishing authority

throughout the island, and at the same time ensuring protection to commerce in the Irish Sea by preventing raiders leaving *from* the natural gateway of the country. Although clansmen might remain virtually independent in the distant hills, the lord of the central lowland was virtually the King of Ireland. This is, when one considers it, obvious, although at first sight remarkable in view of the by no means favourable conditions of the whole of the central lowland.

## The western fringe

This seems a convenient designation for a belt of country lying between the central lowland as here described and the old mountains of the northwest. Actually it consists of two contrasted types of country. There are areas where the Carboniferous Limestone reaches the surface and gives rise to dry limestone country covered with sparse sheep pastures, and other areas where the surface soils are of glacial origin but comprise comparatively well-drained mounds or drumlins and eskers. These mounds of sandy glacial material contain few boulders, so that stone is not available for the construction of

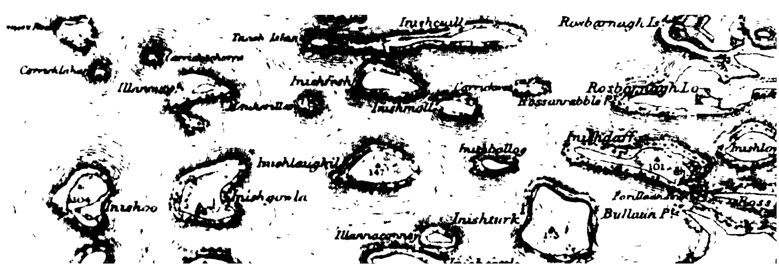



FIG. 269. Clew Bay — an example of 'drowned' country of drumlins
Scale, 1 inch to 1 mile. Reproduced from the Ordnance Survey map by permission

stone walls. Instead the fields are divided by hedges. On the other hand the western position of the area and the dampness of the climate favour the growth of grass for hay, and the region is to be described therefore as a land of hay and hedges with oats, potatoes and dairy cattle. In addition, especially in the north, there are outlying masses of the ancient metamorphic rocks of the highlands which stand up as hill ranges, particularly out of the limestone country. To consider the two types of land in somewhat greater detail, over considerable tracts the limestone may be almost bare, its grey-white surface seamed with solution channels, and supporting but little vegetation of any sort. This may be the case even on low ground, as to the north of Galway on the shores of Lough Corrib. Frequently the limestone is covered by patches of drift, and fades thus into the drumlin or esker type of country. The lower parts of the valleys near watercourses are often ill-drained and occupied by large bogs. The slopes are cultivated. The lime-

stone blocks are used for the construction of walls, which become grassed over and divide the fields. Oats and other crops are largely grown; both cattle and sheep are numerous, though sheep are specially important. The farmhouses have an air of comparative prosperity, and this belt of mixed soils is obviously an important one. It is thus clearly incorrect that the

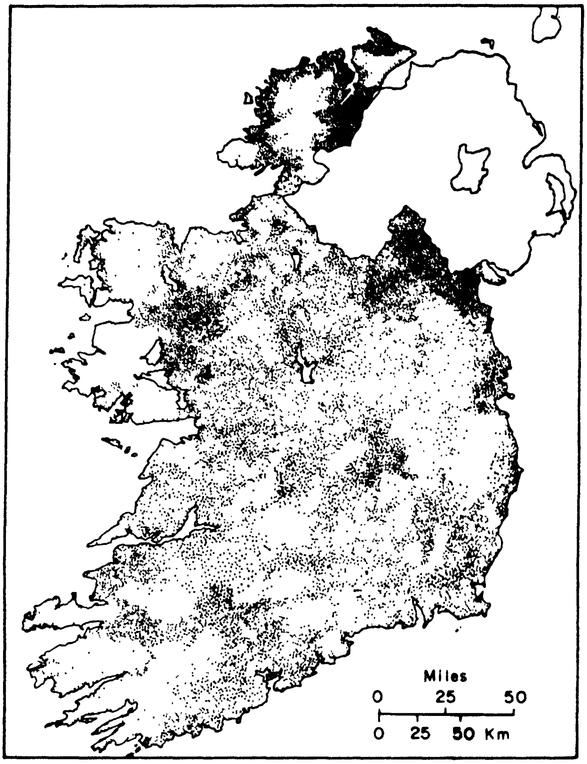



FIG. 270. Distribution of potato cultivation in the Irish Republic in the 1930s
Each dot represents 10 hectares (25 acres)

country though hilly should be linked with the barren desolate tracts of the mountains of Connemara and Mayo by which it is bordered on the west. The glacial country, on the other hand, is built up in the main of a series of drumlins or mounds of glacial material. It would require a map contoured at ten-foot intervals to show adequately its character. But where such country has been drowned, as in Clew Bay, the innumerable low islets give a clue to its general appearance. Near the sea the hollows are drowned, but elsewhere they are occupied by small scattered peat bogs, whilst reedy pastures occur on the more level stretches, the gentle slopes of the mounds being occupied either by cropped land or hay; whilst the driest slopes are

given over to sheep. This type of country is well seen in the plains of Mayo or in the country round Clew Bay, or from Westport to Castlebar and Swineford. It stands out on the agricultural maps as the belt where the cultivation of oats and potatoes is important, and where large numbers of cattle, sheep and pigs are reared. Where masses of the older rocks appear through

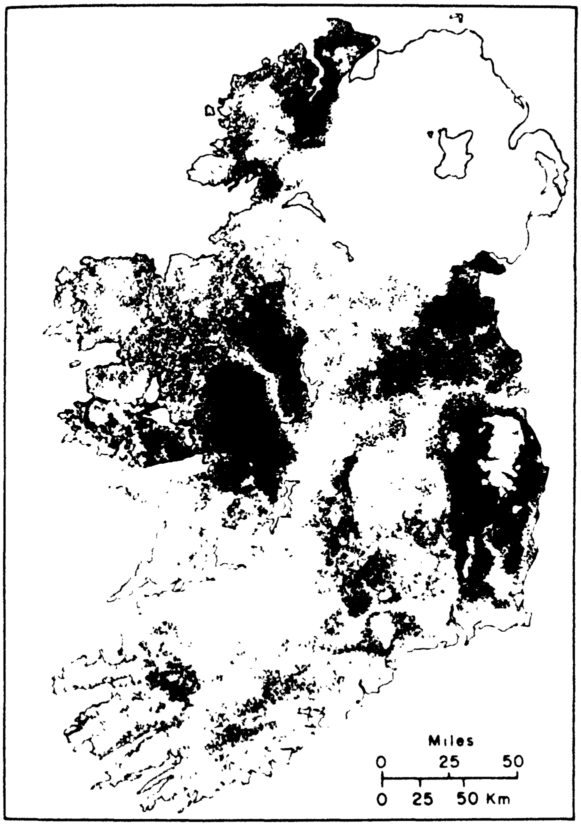



FIG. 271 Distribution of sheep in the Irish Republic in the 1930s
Each dot represents 100 sheep

the limestone or the cover of glacial deposits they give rise to mountains (of which the Ox Mountains may be quoted as an excellent example) forming a sort of outer rampart or bulwark of the Connaught (Connacht) Highlands against the central lowlands.

## The limestone uplands of County Clare

Here in the west is a typical limestone area, but one which has few glacial deposits. There are wide stretches of open grassy moorland comparatively

free from peat, whilst flat-topped hills with abrupt edges, built up of almost horizontal limestone beds, break the monotony of the scenery. These limestone tracts are sparsely inhabited, and support mainly a limited number of sheep. Isolated tracts of a similar character occur fringing Sligo Bay near Sligo itself. In the southern part of County Clare are drift deposits which support pastures and share in the dairy farming industry of County Limerick.

## The southern area of the central lowlands

This, perhaps, is the most difficult part of Ireland for which one may attempt to give a general description. The country of farmland and vast bogs passes southwards into an area where the plains are interrupted by numerous hills. Some of these are anticlinal masses where the older rocks—the Old Red Sandstone—are found outcropping from beneath the Carboniferous Limestone. Others, on the other hand, are synclinal areas where patches of Millstone Grit have been preserved in basins in the Carboniferous Limestone, but owing to their greater resistance to subaerial denudation stand up as hill masses. In the heart of the anticlinal hills of Old Red Sandstone still older rocks appear, and thus one gets barren rocky mountains with poor pasture, such as are found in Slieve Aughty, Slieve Bernagh, the Arra Mountains, Slievefelim, and Slieve Bloom. It will be noticed that in the neighbourhood of Killaloe on the Shannon, just to the northeast of Limerick, two of these masses of ancient rock approach close to the Shannon itself. It is here that the Shannon passes over the rapids from Lough Derg (35 metres: 116 ft above sea-level) before reaching the town of Limerick, and it is the succession of rapids which has made possible the construction of the hydroelectric power works (see p. 351). Between the various hill masses there are broad tongues of lowland or corridors, which can be regarded as off-shoots from the central lowland. These fade southwards into important river valleys. Speaking generally, the valleys afford much cultivated land, especially on the slopes. Oats, potatoes and turnips are grown. In the drier and more sheltered valleys farther to the southeast, barley becomes important. There are also very extensive cattle pastures, and the drier hill slopes above support numbers of sheep, whilst in the centre of the valleys themselves there are often extensive bogs. The easternmost of the larger valleys is that of the Barrow in which sugar beet and mangolds are cultivated. The western part of the whole tract comes within the main dairying belt of southwestern Ireland, and it is here that perhaps the most fertile part of Ireland—the Golden Vale of Limerick—lies between the region now under consideration and that which has been described under southwestern Ireland. On the other hand the northeastern portion of this varied tract is more closely allied with the central lowland and, like the central lowland, is famous for its beef cattle.

## The industries and towns of Ireland

Many of the manufacturers of the Irish Republic are concerned primarily with the processing of home agricultural products. Of outstanding importance is the manufacture of butter and the dairying industry is organised essentially around the cooperatives which collect the milk and make the butter. With a relatively small home urban market there is not the demand for liquid milk which characterises the dairying industry of England, Wales and Scotland, and consequently the emphasis is on butter.

There is an associated cheese industry, though much less important. Mitchelstown, Co. Cork, is the main centre. Butter is made at a large number of rural creameries, and collected in cold stores at Cork and Dublin, whilst the condensed milk trade is centred at Limerick.

An old established industry is that of bacon curing. There are bacon factories at the four chief towns—Dublin, Cork, Limerick and Waterford—as well as in a number of provincial centres. Efforts have been made to spread bacon factories throughout the country in order to provide a convenient market for the pigs produced by the smaller farmers. Some of the factories also provide sausages and other pork products.

Centres of meat canning have also been established, notably at Dublin, Waterford and Roscrea. The home production of sugar from sugar beet has been carefully fostered since 1925 and the output is about enough to supply home needs. There are four factories in the heart of the country at Carlow, Thurles, Mallow and Tuam. Along with the growth of home production of sugar has been the development in the manufacture of jams and confectionery.

Although production of barley is not large, Irish barley has a high reputation as malting barley and goes largely to the breweries found in Dublin Cork and other towns, especially in the east. The most famous and the largest of the breweries is of course that of Guinness beside the River Liffey in Dublin. Irish whiskey is equally famous and distilleries are situated in Dublin, Cork and Tullamore. Irish whiskey is quite distinct in character from Scotch and there is a considerable export market. There has long been a widespread appreciation of the dangers of alcoholism, especially from illegally home-produced spirits and the wide distribution of plants manufacturing soft drinks is an indication of the effects of the abstinence campaign.

Amongst other industries using agricultural products one finds naturally spinning, weaving and dyeing of woollens, with a number of woollen mills as well as a large production of homespun cloths made by individual workers in the west.[1] There are some famous mills near Cork, especially Blarney and Dripsey. Hosiery and knitwear are also to be noted, and the industry has

1. See D. J. Dwyer and L. J. Symons, 'The development and location of the textile industries in the Irish Republic', *Irish Geography*, 4, 1963, 415–31.

spread to the making of clothes and a range of woollen rugs, blankets and tweeds for export. A widespread leather industry and the manufacture of footwear reflects another use of home-produced raw material.

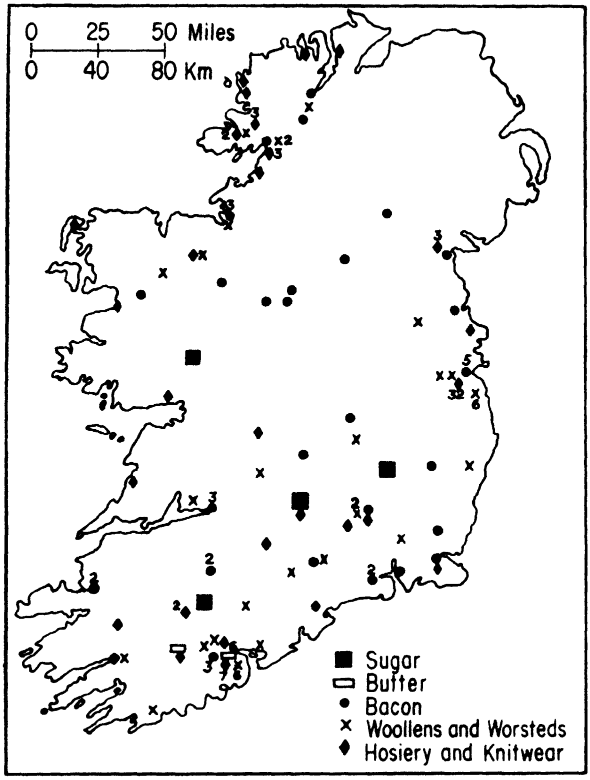



FIG. 272. The industries of the Irish Republic
(*Modified from T. W. Freeman, Ireland, by permission of the author and Messrs. Methuen & Co. Ltd.*)
More than one plant is indicated by a number.

A group of industries is concerned to supply the needs of the farmers, notably with tools and agricultural implements and fertilisers. The milling industry is an interesting one. Few of the old mills still grind the wheat, oats and barley supplied by farmers and return the flour to them after grinding. The mills grinding imported wheat and maize have become important in the bigger towns. Limerick is now a milling centre.

Those industries making goods intended for the home market employ an increasing number of people but they tend to be concentrated particularly in and around Dublin, despite the Government's aim to spread industry widely. Paper and printing affords a good example, whilst one of Dublin's largest factories makes biscuits and chocolate for distribution throughout the country. Other firms are concerned in Dublin, Dundalk and Drogheda with tobacco manufacture. Engineering and metal works have also in-

creased in importance, but it was not until 1938 that steel making was established in Ireland on an island in Cork harbour, a former British naval base with deep-water berths. Ireland's first oil refinery was opened at Whitegate, Cork, in 1959.

A description has already been given in an earlier chapter of the great Shannon hydroelectric power scheme from which electricity is distributed over most of the country, though now providing only a fraction of national consumption. In view of the absence of coal, oil and timber this water power development has been of the greatest importance. The old staple Irish fuel was peat, never a very satisfactory one, although obtainable in many areas just for the labour of cutting and drying. Many isolated habitations and towns have gone direct from a peat age to an electric age. In some cases, oddly enough, the electricity may be generated using peat as a fuel in the power stations (see above, pp. 328, 352).[1]

## The ports of the Irish Republic

The great bulk of shipping which serves the Irish Republic uses the port of Dublin, including its outport at Dún Laoghaire, formerly Kingstown, used by the regular service of mail steamers to Holyhead in Anglesey. Apart from passenger services to Britain, all the port trade is of cargoes as the rapid air services through Shannon Airport in County Clare cater for transatlantic passengers. The numerous small ports have a limited and generally declining coastal traffic.

### Dublin

As regards its navigation, harbour facilities, and internal communications, Dublin is the obvious rival of Belfast, and is far and away the most important port of the Irish Republic. It handles the export trade with Scotland, the Midlands and south of England. There are regular cargo or cargo-passenger services to Glasgow, Liverpool, Manchester, and by the relatively short sea route to Holyhead, with express connections therefrom on the other side. The Liffey on which Dublin stands is but a small river with a small catchment basin, but owing to the lack of gradient the channel in the estuary was formerly shallow and the deposition of sand continuous. Improvements have continually been made to provide deep-water berthage of at least 10.6 metres (35 ft) accommodating the large ocean freighters normally using the port. Larger vessels must wait for high tide to cross the bar over which there is 6 metres (20 ft) of water at low tides, thus enabling the port to be used by cross-channel steamers at all times. Constant and extensive dredging, however, will always be necessary. Above the loopline railway bridge steam lighters come up to the breweries of Messrs Guinness at St James's.

1. Chapter 8, 'Peat', in *A View of Ireland*, British Association, Dublin, 1957.

The port is equipped for the bulk handling of oil and of various other commodities but side by side with modern methods of loading and off-loading may be seen numerous horse-carts and the handling of goods by hand-cranes. There is no direct passenger railway service in connection with the quays and this has diverted traffic to Dún Laoghaire, which has direct rail connections. The port of Dublin itself, however, is so near to the heart of the city that the absence of rail facilities is no great disadvantage and there are several regular, but not daily, passenger sailings to ports in Great Britain, other than the daily service to Liverpool. The once-important Royal Canal is disused and the Grand Canal system which once linked Dublin with a large part of the heart of the island has become merely a pleasure route, as barges ceased to run in 1959. Nevertheless rail, road and water place practically the whole of the Irish Republic in the hinterland of the port of Dublin.

In view of the absence of home production of coal there is everywhere throughout Ireland a demand for imported coal in large quantities, though the railways now run on diesel oil. Naturally Dublin is still the chief importing port and it is to Dublin that are sent most of the manufactured goods

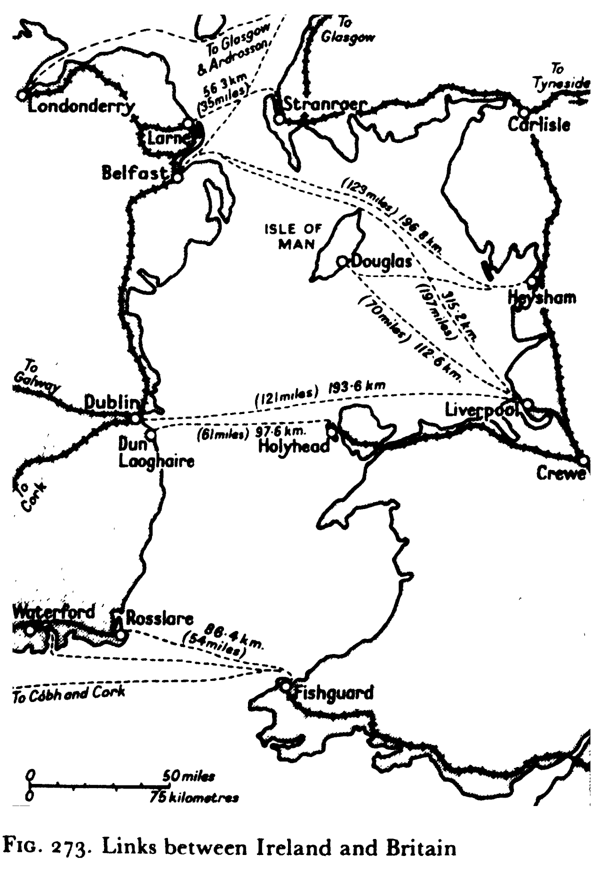



FIG. 273. Links between Ireland and Britain

for distribution throughout the Republic. As a collecting centre for commodities for export Dublin is also pre-eminent. More than a third of the exports of the Republic are live animals, cattle in particular, but also sheep and pigs. There is in addition the movement in both directions of racehorses and bloodstock and even greyhounds, which travel by air. Live animals demand quick and efficient transport, hence the advantage in the situation of Dublin, only 98 kilometres (61 miles) from Holyhead and 162.5 kilometres (121 miles) from Birkenhead. Fat stock rapidly lose condition and the time taken in crossing is very important, hence they are commonly sent to Holyhead and Birkenhead. Store cattle destined either for fattening or addition to the dairy herds of Britain are not so affected by a longer voyage and may go to other ports.

Though there is still a large export in stout and porter manufactured in Dublin the establishment by Messrs Guinness of breweries elsewhere, notably at Park Royal in the west of London, has considerably altered the position in recent years.

Most of the other exports from Ireland will be found passing through Dublin, which also handles a large part of the import traffic, less important than formerly, of feeding stuffs for animals. By contrast the coastwise traffic from Dublin is less important than from many of the smaller ports.

Although the harbour of Dún Laoghaire, or Kingstown, was built as long ago as 1817 as a refuge for vessels during south-easterly gales, it was developed as a result of interest of the railway companies into the premier passenger port of the Irish Republic, favoured by the short distance from Holyhead in Anglesey, terminus of the 'Irish Mail' rail route to London. Its old rival was Rosslare, in the southeast with a service from Fishguard on the former Great Western Railway.

## Other ports

North of Dublin is the small port of *Dundalk*, importing coal, but more important is *Drogheda*, which has a considerable import of coal. The port, however, is poorly equipped and though small ocean vessels use the port cargo has to be unloaded by gangways and there are no direct rail facilities to the quayside.

Southwards from Dublin is the small port of *Wicklow*, importing a little coal, but more significant is *Arklow*, which was developed as the Republic's largest fishing port. Like the other ports of the east coast, however, its significance has faded as Dublin's has been improved, but it imports china clay for a local pottery.

The small port of *Wexford* lies at the mouth of the Slaney and is served direct by railway, but more significant is *Rosslare* harbour, almost an eastern continuation of Wexford, where passenger and goods trains run alongside the vessels moored to the quay. Goods can be distributed with considerable facility to the south and southwest of Ireland. As a passenger port it has

therefore long rivalled Dublin, to which it also occupies second place as a cargo port. Though the sea passage is about the same as Holyhead–Dublin, the overall time of the journey from Cork to London *via* Rosslare is between two and three hours shorter than from Cork to London *via* Dún Laoghaire and Holyhead.

Along the south coast of Ireland the port of *Waterford* lies in a sheltered estuary where the combined Nore and Barrow are joined by the Suir. It is, however, open to small ocean-going vessels only at certain states of the tide, and the city and port of Waterford on the south side of the river are cut off from the railway on the other side. Formerly river traffic by barges inland was significant and at that time the port took a large share in the export of live animals.

*Cork* is the second port of the Irish Republic and the very large sheltered harbour includes the lower harbour of Cork itself as well as Cóbh or Queenstown situated on the south side of Great Island and with a quay adjacent to the railway station for reception of mails and passengers. The new oil refinery at Whitegate is on Cork Harbour. Other very small ports along the south coast include Kinsale, Baltimore and Youghal.

*Bantry Bay*, one of the west-facing rias on the southwest coast, has recently become an oil terminal. With an almost unlimited water depth, it will become the major Atlantic terminal for tankers of up to 300000 tons employed by the Gulf Oil Company. The oil will be transhipped into smaller tankers for distribution to British and continental European ports which are unable to accommodate such huge vessels. In terms of shipping tonnage Bantry Bay will quickly become the largest port in Ireland.

Turning to the west coast of the Irish Republic exposure to westerly gales is a serious deterrent to the use of those ports which exist, which is unfortunate in view of the fact that Limerick at the head of the Shannon estuary, a tidal port for all vessels, includes the whole of the Shannon basin in its natural physical hinterland. Fifty-eight kilometres (36 miles) from the open sea, on the south side of the estuary, is Foynes, which achieved a greater importance as a trans-Atlantic airport, formerly used both as a regular stopping place as well as for emergency landings when the airports of Britain were fogbound. It has been replaced by Shannon on the north side of the river.

Midway along the west coast, protected by the Aran Islands, is Galway Bay, a deep indentation reaching the plain of central Ireland. Unfortunately, however, the approach to *Galway harbour* is not favourable to shipping because of the natural shelving which takes place and the existence of a ridge of hard rock crossing the channel, which can only be blasted away, not dredged. There have been many proposals to develop Galway as a trans-Atlantic port, and for some years from about 1926, trans-Atlantic liners anchored in the roadstead a mile or so off the port and transferred their passengers by tender. But all one is likely to see in Galway harbour now is a few fishing vessels, probably from Scotland, and occasional coast-

ing ships bringing coal, raw materials for the various industries of Galway, including fertilisers, and bags of cement as building materials. And most of the other small ports are similar, such as Westport and Ballina (on Donegal Bay), Sligo (on Sligo Bay), and Ballyshannon on the northwest side of Donegal Bay.

## The foreign trade of the Irish Republic

The diagrams illustrating the foreign trade of the Republic (Figs 274, 275) show at once the overwhelming importance of the exports of agricultural origin, but there has been a significant change since the Second World War, as now the export of meat in various forms—mainly beef, some bacon—exceeds that of cattle. In effect this indicates both the industrial growth in the Republic and the humanitarian objections to the export of live animals. Eggs and poultry exports have now practically ceased as a result of the intensification of British poultry farming, but butter exports have increased with the use of cold storage plants giving supplies throughout the year. Still, however, some live animals are exported, including cattle for immediate slaughter as well as stores for fattening. There is also an export of sheep and lambs, and an important bloodstock trade. Beer and whiskey also form important exports. The imports into Ireland bring out the dependence of the

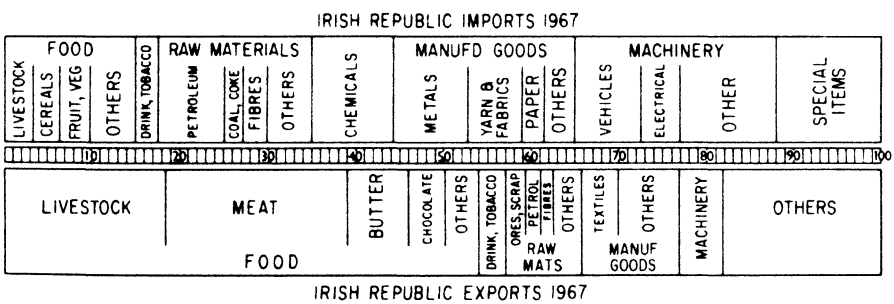



Fig. 274. Trade of the Irish Republic, 1967

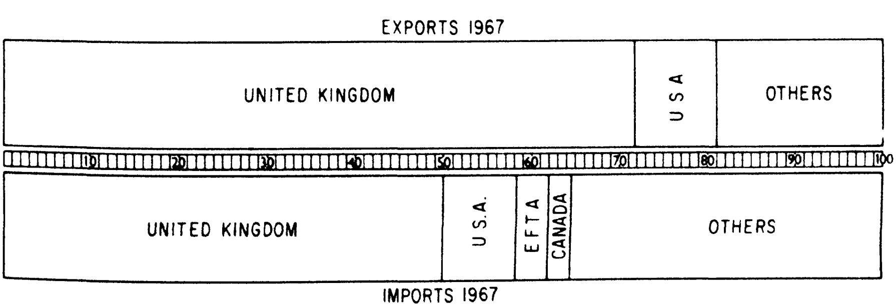



Fig. 275. Trade of the Irish Republic by countries, 1967

country on foreign supplies of coal, petroleum and many manufactured goods as well as its dependence—as is true also of the United Kingdom—on foreign supplies of the essential foodstuffs. As we have shown elsewhere in this book, wheat used to be grown over large areas in Ireland, but one must admit that the geographical conditions of the country are quite unsuited to the production of this crop, and it cannot be grown economically in competition with other countries of the world where the geographical conditions are more suitable, as in Canada or Australia, though production is encouraged by Government.

There are, then, three special aspects of the foreign trade of the Irish Republic worthy of notice. In the first place, Ireland sells various commodities, particularly foodstuffs which are not produced in sufficient quantity in Britain, to that country; whilst Great Britain supplies manufactured articles that cannot be made in Ireland. It is not surprising, therefore, to see that the Republic in 1967 sold 60 per cent of all its exports to Great Britain and a further 12 per cent to Northern Ireland and purchased over 50 per cent of all its requirements from the same sources. A feature of recent years has been the large import from the United States.

The second point is that in the supply of agricultural products to Britain, and indeed to any other country which may serve as a market for these goods, the Irish Republic has a great rival in Denmark. But in the third place the contrast with Denmark is interesting. Ireland's leading exports are live cattle and meat, Denmark relies on butter and bacon. An interesting geographical comparison can be made between the Irish Republic and Denmark, both countries hampered to some extent by natural geographical conditions—Ireland by too much rainfall and a poor drainage, and Denmark by a poor soil. Denmark has achieved success in her dairy farming industry largely as the result of carefully planned cooperation amongst the small farmers. Ireland is treading the same path as far as her dairy farming industry in the southwest is concerned. No geographical reasons really exist why Ireland should not attain the same success as Denmark has achieved.

# 30
# Northern Ireland

Under the Government of Ireland Act, 1920, as subsequently amended in certain details, a separate parliament and executive government were established for Northern Ireland, comprising the parliamentary counties of Antrim, Armagh, Down, Fermanagh, Londonderry and Tyrone, together with the Boroughs of Belfast and Londonderry. Although the name Ulster is often used as if synonymous with Northern Ireland, in fact Northern Ireland embraces only six of the nine counties of the historic province of Ulster; Donegal, Cavan and Monaghan are included in the Irish Republic.

In broad general terms Northern Ireland is that part of the island where, largely for historical reasons, Protestants form either an absolute majority or a substantial minority of the population. Over the whole, Protestants form about two-thirds of the total. By contrast in the Irish Republic, Roman Catholics practically everywhere form a majority and over about half the country the population is almost exclusively Catholic.

Northern Ireland forms an integral part of the United Kingdom of Great Britain and Northern Ireland which, since 1921, has replaced the United Kingdom of Great Britain and Ireland. It returns twelve members to the House of Commons sitting in London but its own Parliament has power to act in a wide range of matters. The importance of separating statistics which refer to the United Kingdom from those which refer only to Great Britain (England, Wales and Scotland), or to England and Wales alone has already been emphasised.

Northern Ireland contains 13 577 square kilometres (5242 square miles) or 1 358 838 hectares (3 355 156 statute acres) of land (excluding water), with a population which has been slowly increasing since the beginning of the century and reached 1 484 800 in 1966. In marked contrast to England 40 per cent of these people are classed as rural and 30 per cent actually live in the open countryside—contrasted with about 10 per cent in England—where the isolated family farm averaging 16 hectares (40 acres) is the characteristic unit of settlement. Although thirty-six places have the official status of 'towns' only four, Belfast (400 000), Londonderry (56 000), Newtown Abbey (47 000) and Bangor (27 000) had more than 25 000 persons in 1966, and only ten of the others had more than 10 000. The greater part of Northern Ireland is, in many ways, the Belfast Region.

The close connection in geological structure and relief between Northern Ireland and Scotland is paralleled by human associations between the two countries through the ages, especially from the time when the Scots from northeastern Ireland overcame the Picts in Argyll and gave their name to Scotland. To this day such western Scottish clan names as Macrae are found in Irish form (Rae or Rea and O'Rea) in Ireland. Following the long delayed conquest of Ulster by the English in the early seventeenth century was the organised plantation of English and Scottish settlers, followed by a steady settlement of Scottish Presbyterians and English Episcopalians. Thus the contrasts between Northern Ireland and the Irish Republic are deep rooted: further, the rise of industrialism in Belfast was on the English model. Also, the markets for Northern Ireland's main products, ships and textiles, lie either in Britain or beyond.

## Regions of Northern Ireland

Since in Northern Ireland are to be found continuations of the great structural units of Scotland from which the country is separated only by the North Channel with an average width of a little over 32 kilometres (twenty miles), it might be expected that Northern Ireland would fall into three primary divisions:

(*a*) The northern mountains akin to the Highlands of Scotland lying north of the great boundary faults.
(*b*) The continuation of the Midland Valley of Scotland occupied by the Carboniferous Limestone and other Carboniferous rocks.
(*c*) The continuation of the Southern Uplands of Scotland comprising the country to the south of the boundary fault.

Actually, however, the structure is complicated by the fact that the Chalk Sea spread over the greater part of Northern Ireland and wore down the ancient rocks and deposited over them, as well as over the rocks of the Midland Valley, thin layers of chalk. At a later date, that is in the Tertiary Period, these beds of chalk were covered by enormous stretches of basaltic lavas poured out from great fissures. Hence there is a huge lava plateau over a large part of the country. But this lava plateau has subsided towards the west-centre, where it is occupied by the shallow water of the largest lake in the British Isles, Lough Neagh, and the Bann valley. There is thus at the present day a rather remarkable contrast between the higher parts of the lava plateau around its rim and the subsided central portion. The regions which result, which are both natural or physical regions and agricultural regions, have been shown in Fig. 263. It must also be remembered that Northern Ireland was severely glaciated during the great Ice Age, so that soil and loose rocks were removed from the higher levels of the old rock masses whilst the lower levels were covered with a thick though irregular

mantle of glacial deposits. Great numbers of drumlins cover much of the country.

## The uplands of County Down and County Armagh

This unit is convenient because the region is a natural continuation of the uplands of southern Scotland. There are to be found the same Ordovician and Silurian sediments, but they are in Ireland masked to a greater extent by glacial deposits. There is a further contrast with Scotland in that the whole tract is of lower elevation. Only limited areas rise to over 150 metres (500 ft), and so instead of wide tracts of moorland are miles of pleasant farming country. To the east, indeed, the uplands pass into fertile lowlands which are in turn covered by the shallow waters of the sea in Strangford Lough. Broadly speaking, in the higher parts the soils are stony and poor,

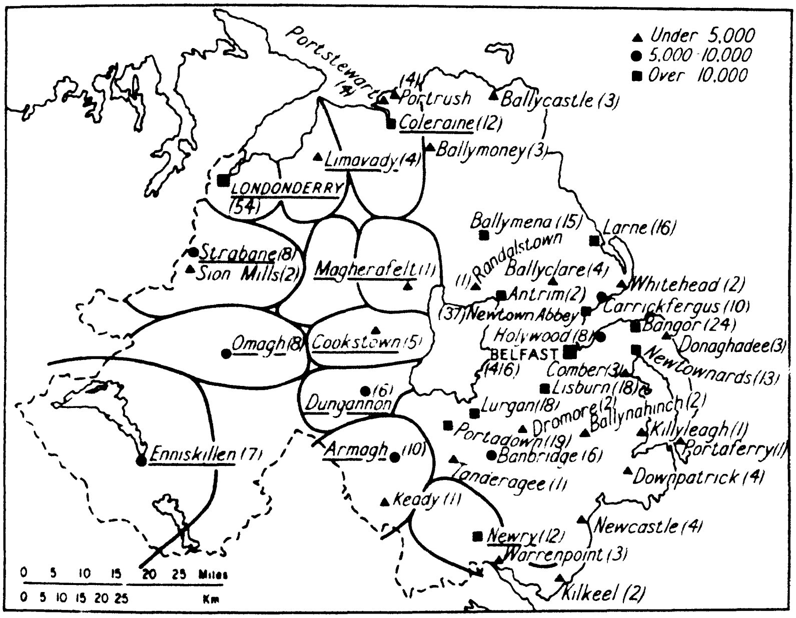



FIG. 276. The market towns of Northern Ireland

The population of each town in 1961 is indicated to the nearest thousand. In the west the large area served by the market town (underlined in each case) is shown by the heavy lines

the farms small, the farmhouses unpretentious, and sheep pastures an important feature of the surrounding land. The lower undulating country, on the other hand, is a land of relatively prosperous farms, and over all this lower ground cattle, dairy as well as beef, are widely distributed; barley, oats and potatoes are leading crops. Taking the region as a whole, sheep are very numerous; their concentration in the higher areas is very marked. The region is generally well populated; market towns are numerous. To the north lie the industrial towns of the Lagan Valley; the rather deserted port

of Newry, once a rival to Belfast, lies in an important fertile valley to the southwest, while the prosperous seaside resorts of Bangor and Newcastle are both within this area. The proximity of these considerable areas of settlement, but more especially the proximity of Belfast with its population approaching half a million, has a marked influence on the agricultural occupations of the population.

That part of the region lying in County Armagh differs somewhat from County Down. It is a county of small-holdings, focusing economically on Portadown, where jam factories are found. In the south of the County Down upland belt is a distinct region, small but remarkably well defined—the Mourne Mountains, formed by a great intrusive mass of granite of comparatively recent age, probably Tertiary. The mountains are rounded in outline, but they rise in Slieve Donard to 852 metres (2796 ft) above sea-level. Cultivation is absent from the central mass, but very large numbers of sheep are reared on the rough pastures of the slopes and there are some recent conifer plantations. The mountains themselves reach the coast in Carlingford Lough, which may be described as a fiord, and also to the south of Newcastle; but between these two points there is an interesting tract of lowland centring on Kilkeel, which is a tract of small farms and sheep pastures, but where oats and potatoes can be grown in quantity, and where many cattle are kept. Seed potatoes from this area are widely exported.

Since other hill masses, coinciding with other intrusive igneous rocks, lie to the west of Carlingford Lough, Estyn Evans uses the name Carlingford Lough Mountains to cover both these and the Mourne Mountains.

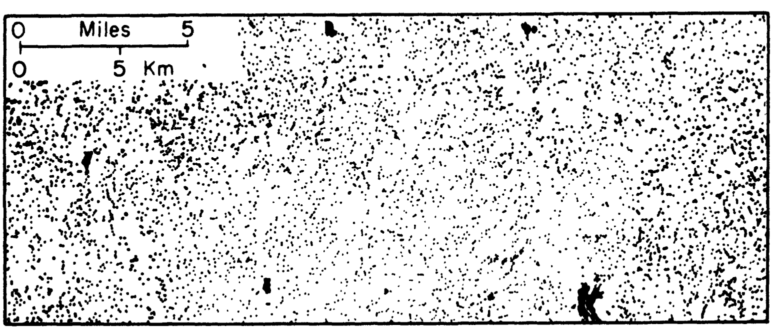



FIG. 277. Map indicating the scattered nature of rural settlements in Ireland

Each dot represents a single inhabited house, but there are only five villages in the whole area That marked in the southeast is Newry.

## The plateau and glens of Eastern Antrim

This region comprises the higher eastern portions (the land over 150 metres (500 ft)) and the edge of the basalt plateau, together with the coastal strips which sometimes lie between the edge of the plateau and the sea, and also

the deep glens which gash the edge of the plateau itself. Agriculturally, these three parts are to a considerable extent distinct:

(*a*) The surface of the plateau is wide open moorland, useful as pasturage for a limited number of sheep and cattle.
(*b*) The coastal strips vary greatly. Sometimes there is a low plateau with a rolling surface formed by the basalt itself, as in Island Magee southeast of Larne. Such country is fertile, and dairy-farming may be important. In the northeast of Antrim there is a considerable tract of ancient rock—a continuation of the Highlands of Scotland—cropping out from beneath the chalk and the basalt. These rocks give rise to boulderstrewn moorland sheep pastures, whilst on sheltered valley slopes many small mixed farms may be found. In a few places tracts of chalk are exposed, and there is a sudden change to short springy grass which is indistinguishable, except to the botanist, from that to be found on the chalk down of southern England; and the white chalky farm lanes and the numerous sheep make the comparison complete.
(*c*) The deep glens are particularly interesting. They are, of course, famous for their scenery. The summer visitor might be surprised if he observed the conditions of these glens in the winter. They are narrow and bordered by high, often vertical, basalt cliffs, so that the southern side of the valley may not be in sunlight in the winter until as late as 2 p.m. and suffers accordingly. Agricultural conditions and the health of the people improve as one goes to the other side of the valley. In general, the centre of the valley is occupied by ill-drained cattle pastures, and on either side of the road or lane, along the valley side, is a succession of small farms where the farmer carries on a varied mixed farming. In the broader glens and on part of the coastal strip, particularly on the northern shores of Belfast Lough—Belfast to White Head—Keuper Marls appear and afford excellent soil capable of intensive cultivation. No one needs to be reminded that where the basalt reaches the northern coast is to be found the most famous of all localities in the whole of Ireland—the Giant's Causeway—the stones of the causeway being naturally formed hexagonal columns of basalt. Larne serves as an outpost for Belfast on the short sea route to Stranraer in Scotland, but the other little ports at the mouths of the glens—Glenarm, Cushendun, Cushendall and Ballycastle—occupy themselves with summer visitors.

## The Lagan Corridor

The Lagan Corridor, only a few kilometres wide, lies between the basalt edge on the north and the uplands of County Down. It is the trough in which Belfast lies and which opens out in Belfast Lough.

## The Lough Neagh Basin and the Lower Bann Valley

Except for the west, the greater part of Northern Ireland may be described as the Ulster Basin, in that a great tract of it drains towards Lough Neagh;

agriculturally and otherwise, however, it seems better to separate the lower central part of the great basalt region which lies almost entirely below 150 metres (500 ft). The underlying basalt is often hidden by the glacial deposits, and there is a gently rolling surface rather than a level plain. If the basalt itself is exposed, there is often a rich, red-brown, fertile soil, but in many places the gentle slope towards the central lake has waterlogged glacial soils, though the lighter glacial deposits may be well drained. Thus there are some true fens and large areas of damp pastures characterised by clumps of rushes. However, considerable drainage work has substantially increased the numbers of cattle such land can support. Where drainage and soil conditions are better, arable land is found. This is particularly the case on the superficial clays and alluvium lying to the southwest and west of the lake. Here oats are grown in quantity, and in the heyday of the flax industry this region was the great area of flax cultivation which was particularly important in the valley of the Main. A basalt ridge separates the Main and lower Bann valleys, and rises to over 150 metres (500 ft). This is sufficient to render cultivation unimportant and to bring in sheep pastures. Otherwise sheep are unimportant in the basin itself. In the broad lower Bann valley, centring on the small port of Coleraine, mixed farming is typical.

### The mountains of Londonderry and Tyrone

Geologically this area is part of the ancient massif of Donegal from which it is separated by the broad, fertile valley of the Foyle. The highest parts form the Sperrin Mountains, rising to 683 metres (2240 ft), whilst near at hand is to be found the high western edge of the basalt plateau. The higher areas of both the basalt and the ancient rocks are unoccupied save for a few sheep, though recent afforestation has changed the appearance of peaty slopes. Towns and large villages are absent over the greater part of the area, the inhabitants being found in small isolated farms in the valleys. Here the valley farmers have a few cattle and a few pigs, and succeed in growing crops of potatoes—perhaps some oats; but other crops are unimportant. The valleys open out westwards into the Foyle Valley.

### The Foyle Valley and the shores of Lough Foyle

The significance of this corridor connecting the lowlands of central Ireland with the port of Londonderry has already been stressed. It is sheltered from the rain-bearing westerly winds; there is much arable land devoted especially to oats and to a much smaller extent to potatoes and turnips. As a result of this cultivation, the area of cultivated land in County Derry almost balances the area under permanent grass. The Foyle Valley has already been likened to a Scottish strath. In its continuation northeastwards along the southern shores of Lough Foyle there is a wide stretch of marine alluvium largely given over to cattle pastures, and further inland a belt of low-

land floored by red Keuper Marls which give good arable land, and which may therefore be said to correspond roughly to a Scottish carse.

### The Rift Valley lowlands

To the southwest of Lough Neagh there is a corridor of lowland which connects the Lough Neagh basin with the central lowland in the Irish Republic. It lies between the ancient metamorphic rocks of the Sperrin Mountains on the north and the Ordovician-Silurian sediments on the south. Structurally it is, of course, a continuation of the rift valley, or midland valley, of Scotland. As in the midland valley of Scotland, there are large tracts of Old Red Sandstone which give rise to an extensive hilly region northeast of Lower Lough Erne, in the basin of the upper Foyle around Omagh. As in Scotland, too, there are Carboniferous sandstones and shales giving rise to an area of hills to the northeast of Upper Lough Erne. The remaining area consists largely of Carboniferous Limestone worn to a lower level and masked by glacial deposits, as in the ill-drained tracts of the central lowland. This forms hummocky lowlands with the hollows frequently occupied by shallow, tortuous-sided lakes. The region includes the greater part of Fermanagh, the southern portion of Tyrone, and Derry, the main centre of the area being Enniskillen between Upper and Lower Lough Erne. Where this corridor links with the corridor of the Foyle valley is the town of Omagh, whilst Armagh is on the southern fringe of the area. It is on the whole a region of small, scattered farmsteads, whilst here and there only are there tiny market towns such as Aughnacloy. Dairy and store cattle are numerous, pig production is fairly widespread. Oats are grown only in more favoured tracts.

## Industries and industrial regions

One-third of the population of Northern Ireland lives in *Belfast*, which has become a great manufacturing centre with a population approaching half a million. In Northern Ireland as a whole nearly 200,000 persons are employed in manufacturing, and 55 per cent of these in 1962 were at work in Belfast itself, though many travelled daily from their homes in towns and villages over a wide area. The development of industrial Belfast is remarkable because Northern Ireland is practically devoid of native resources of power or minerals and, with only a small home market, is separated by the Irish Sea from its principal domestic markets.

Shipbuilding is virtually synonymous with the one firm of Harland and Wolff, whose modernised shipyards, employing 9000 people, can undertake the construction of the largest tankers, liners, cargo ships and special purpose vessels including warships. Their huge engineering works can supply the necessary propelling machinery (see Chap. 16). In combination with Short Brothers, formerly of Rochester, Kent, an aircraft industry has

been developed by the shipbuilding interests—at first flying-boats, then heavy bombers, and later jet aircraft. Active Government encouragement has been given to the expansion of light engineering works such as those producing precision instruments, radios, vacuum cleaners and machine tools (see p. 453). This is in addition to the older range of textile, agricultural and other machinery. The textile machinery is a natural corollary

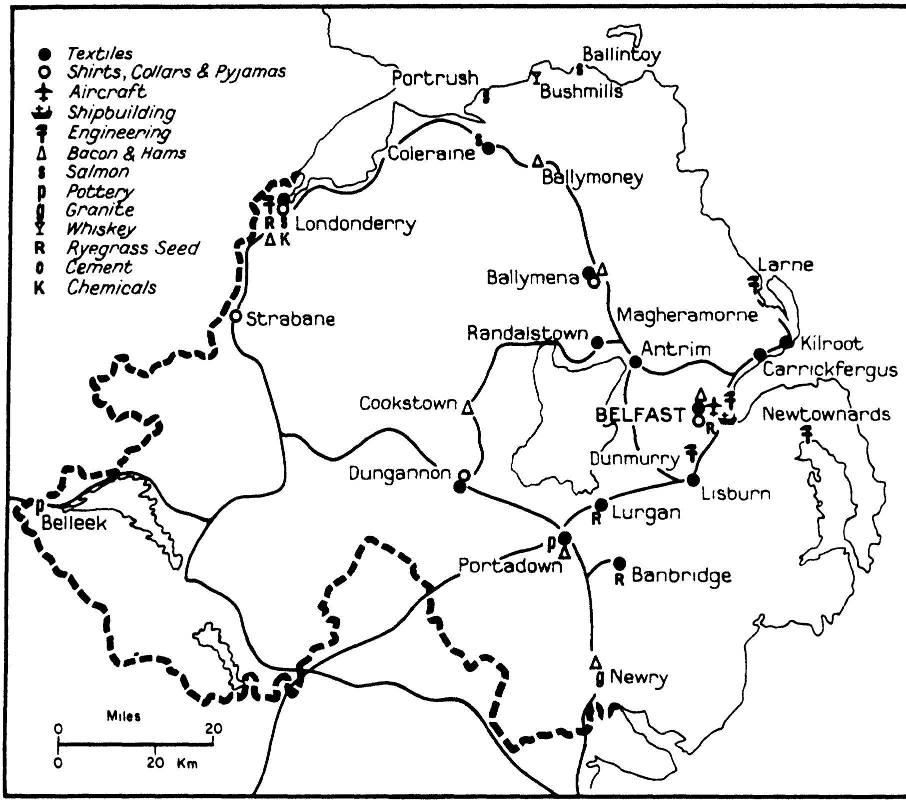



FIG. 278. The towns and industries of Northern Ireland
See also Fig. 199 (p. 567).

to the other great industry, that of textiles, which employs nearly half the total of industrial employees—70 per cent of them women. The textile industry has undergone great changes since the Second World War, with the declining importance of linen and much increased emphasis on manmade fibres, into the manufacture of which an enormous amount of new British, American and continental capital has been poured, with great new plants at Carrickfergus, Kilroot, Limavady, Antrim, Coleraine and elsewhere (see p. 576). Northern Ireland, indeed, produces almost one-quarter of all the synthetic fibre output of the United Kingdom. Cotton and wool textiles are still made, as well as a large output of ropes and cordage, whilst 10 per cent of the textile workers are engaged in making up materials into sheets,

cloths, handkerchiefs, etc., apart from the actual textile industry. There is an expanding carpet industry.

Two other groups of industries in the Belfast area call for notice. One is the processing of home agricultural products—bacon-curing, canning of milk and vegetables, grain milling, baking, brewing and distilling. The other is associated with the imports of a great port, and includes the tobacco industry and a new oil refinery.

*Londonderry* has an industrial life of its own with an emphasis on clothing such as shirts and collars.

## The ports of Northern Ireland

The port of *Belfast* dominates Northern Ireland. The sheltered, easterly facing Lough made it worth-while to dredge and maintain a navigable channel for the largest liners afloat. This was facilitated by the nature of the materials filling the old trough (cf. Glasgow and Newcastle). The natural hinterland of Belfast—the Lagan valley—soon grew to include the whole region readily accessible through a succession of lowland corridors in due course served by rail and road. Formerly canal transport was possible from Belfast *via* the lowland corridors to distant parts of Ireland. With its superior facilities for dealing expeditiously with passenger traffic (overnight or by day direct to Heysham or Liverpool), with live cattle, perishable products such as eggs and poultry, as well as the bulk handling of coal and grain, and more recently of oil, Belfast has almost eliminated its older rivals. It handles 60 per cent of the seaborne trade of Northern Ireland (or 90 per cent of the total trade including the land boundary and Belfast airport). Wharves and other facilities are being extended, and the channel further dredged. The most valuable items in the export list are textiles and textile machinery.

*Londonderry*, the second port, is at the head of Lough Foyle, twenty-five miles from the open sea on a very stormy coast. As a port it was greatly improved during the Second World War. Above Londonderry the Foyle is navigable for barges till the canal though Strabane is entered. The natural hinterland of the port is the basin of the Foyle: it has been extended further by railways. The export traffic is characteristic of all Irish ports other than Belfast. Agricultural products dominate but are small in total value, and include an increasing number of cattle, sheep, bacon and hams, and eggs (the Londonderry area specialises in the last three). Small quantities of pigs, oats, meal, hides, grain, offal, potatoes and grass seed are exported—the same type of traffic as is exported through the port of Belfast from the Lough Neagh basin. The manufactured products consist chiefly of textiles.

There remain to be considered three other small ports in Northern Ireland. The most important of these is *Larne*, at the mouth of the entrance to Larne Lough, twenty miles northeast of Belfast and, therefore, nearer to

the Scottish mainland. To this factor the importance of the daily passenger service to Stranraer was due.

*Coleraine* is a very small port on the River Bann four and a half miles from the sea.

Although the Newry river was canalised to connect the Carlingford Lough with the Lough Neagh and Lagan basins, the port of *Newry* is only just within Northern Ireland and much of its former hinterland lay across the present frontier. Further, its way to the open sea is obstructed by a bar.

## Trade

The trade of Northern Ireland in a recent year is shown in Fig. 279. On the import side, equipment for the country's industries, and motor vehicles, loom largely, whilst the raw material for the textile industries occupies but a very minor place. Of the exports, however, textiles are the largest individual item; livestock and food products are important, whilst the item 'machinery &c' includes the ships launched at Belfast.

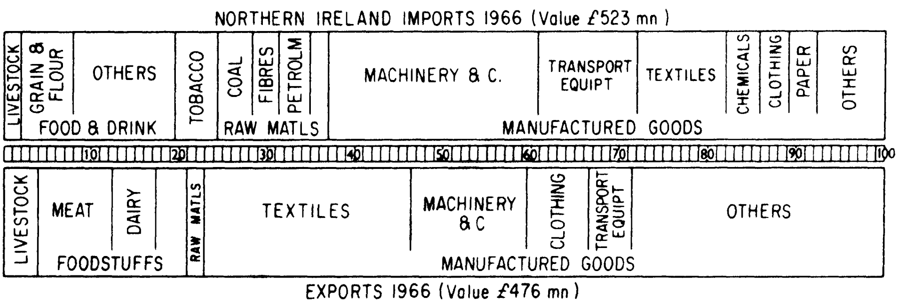



FIG. 279. The trade of Northern Ireland

# 31
# The foreign trade of the United Kingdom

In early times and during the Middle Ages the great feature of English trade was the export of raw materials and the import of manufactured articles. For long the most important of the exported raw materials was wool, but it was only one of several, the export duties levied on which furnished a large part of the revenue of the Crown. In order to collect this revenue, trade was regulated at an early date from the reign of Edward III, and particularly by the Ordinance of Edward III in 1353. This decreed that all the more important commodities (which were named and formed thus the staple commodities) should be exported exclusively through certain English, Welsh and Irish ports where the duties would be collected. The staple commodities enumerated are wool, sheepskins with the wool on, leather or hides, and tin; but on other occasions lead, cheese, butter, alum, tallow and worsted are also mentioned; the last, however, infrequently. The ports specified include most of those of any significance on the east coast of England except Berwick-on-Tweed, together with Southampton and Exeter on the south coast and Bristol on the west. Carmarthen was the sole staple port for Wales. In Ireland there were four: Dublin, Cork, Waterford and Drogheda.

The trade in the staple commodities was mainly in the hands of a privileged body known as the staplers who were, for the most part, foreigners. This was largely, it may be said, because Englishmen were liable to smaller dues than foreigners, and thereby the revenue of the king suffered. Amongst the foreigners engaged in the staple trade of England were many Italians, but members of the Hanseatic League were particularly important (see p. 726). English merchants therefore specialised in the trade in non-staple commodities. Their attempts at trading were adventurous, and hence they became known as Merchant Adventurers and as such constituted themselves into organised companies. As English manufactures grew these became the most valuable commodities outside the staples. Woollen goods were the chief commodities whose sale abroad was pushed by the Adventurers. The Merchant Adventurers had a charter granted to them as early as 1404, and shortly afterwards the company established its headquarters at Antwerp. Other companies followed, such as the Eastland, the Levant or Turkey, the East India, the Africa or Guinea, as well as the Hudson's Bay Company. The East India Company obtained its first charter on 31 Decem-

ber 1600, and retained a monopoly for trade with India until 1813, and with China until 1833, by which time the company had become a great territorial power. But in the fifteenth, sixteenth and seventeenth centuries English manufactures gradually became the principal exports. Throughout the eighteenth century woollens were the most important, and every effort was made to check the rise of rivals. In the course of the eighteenth century cotton goods came to acquire a very considerable importance, and were sent in quantities from Bristol and Liverpool to West Africa to be exchanged for the slaves to be sold in the West Indies. The Industrial Revolution resulted in the placing of cotton manufactures first amongst our exports, a position which they continued to hold until the nineteen-thirties. To give an example of the position in the last century, in the years 1871–75 (average), cotton manufactures represented no less than 31.3 per cent of the total exports, followed by iron and steel 12.9, and woollen manufactures about the same quantity. At that time coal and coke were only about 4.3 per cent. Half a century later the position was still substantially the same, though with the broadening of the country's industrial base the dominance of the major items was slightly less. In 1911–13 cotton represented 25.6 per

*United Kingdom, exports of native produce and manufactures*

| PRINCIPAL ARTICLES | PERCENTAGE OF TOTAL VALUE | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1881–85 | 1886–90 | 1891–95 | 1896–1900 | 1901–05 | 1906–10 | 1911–13 | 1926–30 | 1931–35 | 1950 | 1962 | 1967 |
| Cotton manufactures[1] | 31.9[1] | 30.2 | 29.2 | 26.9 | 27.2 | 26.0 | 25.6 | 19.2 | 15.3 | 7.3 | 1.2 | 0.5 |
| Iron and steel | 11.4 | 11.1 | 9.4 | 10.4 | 10.0 | 10.8[2] | 10.4 | 8.3 | 6.9 | 7.2 | 5.3 | 4.6 |
| Coal, coke, etc. | 4.3 | 5.5 | 7.3 | 9.0 | 9.5 | 9.8 | 9.3 | 6.4 | 8.7 | 2.8 | 0.8 | 0.3 |
| Woollen manufactures | — | — | 10.7 | 9.7 | 8.5 | 8.4 | 8.0 | 7.2 | 6.9 | 6.6 | 2.1 | 1.5 |
| Machinery and engines | 5.1 | 5.6 | 6.4 | 7.3 | 6.9 | 7.6 | 7.0 | 7.4 | 8.3 | 14.6 | 22.2 | 20.6 |
| Chemicals, drugs, dyes | 4.2 | 4.2 | 5.1 | 4.9 | 4.5 | 4.3 | 4.3 | 3.5 | 4.7 | 8.1 | 9.0 | 9.8 |
| Linen yarn and manufactures | 2.7 | 2.7 | 2.6 | 2.3 | 2.2 | 2.1 | 1.9 | 1.4 | 1.5 | 1.4 | 0.1 | 0.1 |
| Apparel and haberdashery | 3.1 | 2.8 | 2.7 | 2.6 | 2.4 | 1.8 | 2.1 | 3.7 | 3.0 | 1.6 | 1.0 | 1.2 |
| Leather manufactures including boots | 1.7 | 1.7 | 1.7 | 1.5 | 1.6 | 1.6 | 1.8 | 1.2 | 0.9 | * | 1.0 | 0.6 |
| Hardware, implements, etc. | 2.1 | 1.9 | 1.6 | 1.6 | 1.6 | 1.3 | 1.4 | | | 2.4 | 4.1 | 3.1 |
| Fish | 0.8 | 0.7 | 0.8 | 1.0 | 1.2 | 1.2 | 1.4 | 1.1 | 1.1 | - | | 0.2 |
| Earthenware and glass | — | — | 1.2 | 1.2 | 1.1 | 1.0 | 1.0 | 1.9 | 2.0 | 2.5 | 1.0 | 0.6 |
| Copper and yellow metal | 1.4 | 1.4 | 1.4 | 1.2 | 1.2 | 0.9 | 0.7 | — | | 3.5 | 1.5 | 1.5 |
| Jute, yarn and manufactures | 1.1 | 1.1 | 1.2 | 1.0 | 0.9 | 0.8 | 0.7 | | - | * | | * |
| Spirits[3] | 0.3 | 0.5 | 0.6 | 0.8 | 0.9 | 0.8 | 0.8 | 1.3 | 1.6 | 1.3 | 2.1 | 2.6 |
| Electrical goods, excluding machinery | — | — | - | — | 0.9 | 0.7 | 0.9 | 1.8 | 1.9 | 3.9 | 6.5 | 6.9 |
| Books | 0.5 | 0.5 | 0.6 | 0.6 | 0.6 | 0.5 | 0.6 | — | — | * | — | 0.6 |
| Silk yarn and manufactures | 1.3 | 1.2 | 0.8 | 0.7 | 0.6 | 0.5 | 0.5 | 1.5 | 1.3 | 2.3 | — | * |
| Beer and ale[3] | 0.7 | 0.7 | 0.7 | 0.7 | 0.6 | 0.5 | 0.4 | — | - | * | - | * |
| Ships | — | — | — | — | — | — | — | 1.8 | 1.1 | 1.9 | 1.0 | 1.4 |
| Automobiles | — | — | — | — | - | — | — | 2.4 | 3.3 | 8.1 | 11.1 | 4.2 |

[1] Large quantities of piece goods of mixed materials in which wool predominated were erroneously entered as cotton prior to 1884, annual value about £500 000.

[2] In 1906–10 'iron and steel' includes 'tyres, wheels, axles' to the value of £1.08m, also small amounts of old rails and telegraph wire.

[3] Ex-ship stores. * Less than 1 per cent.

cent, iron and steel 10.4 per cent, coal and coke rather more, at 9.3 per cent, woollen manufactures 8 per cent, and machinery 7 per cent (see table on p. 802). After another two decades that included the First World War and the great depression, the period 1931–35 saw cotton manufactures reduced to 15.3 per cent, iron and steel to 6.9 per cent, and woollen to 6.9 per cent; coal and coke remained high, at 8.7 per cent, for the full impact of oil had not yet been felt, whilst machinery had risen to 8.3 per cent, and electrical goods and automobiles had begun to figure significantly in the list.

The percentages referred to in the last paragraph relate to *values*. If tonnage is taken into consideration the significance of coal is at once apparent since it formed for long more than half the total exports of the country. The huge export of coal reaching a maximum of 76.2 million metric tons (75 million long tons) in 1913 (see above, Chapter 14) not only encouraged the

*United Kingdom, general imports, excluding diamonds and bullion and specie*

| PRINCIPAL ARTICLES | PERCENTAGE OF TOTAL VALUE | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1881–85 | 1886–90 | 1891–95 | 1896–1900 | 1901–05 | 1906–10 | 1911–13 | 1926–30 | 1931–35 | 1950 | 1962 | 1967 |
| Grain and flour | 15.7 | 13.6 | 13.8 | 12.9 | 12.5 | 12.0 | 11.4 | 7.9 | 8.7 | 6.1 | 5.5 | 3.5 |
| *Wheat* | *7.0* | *5.5* | *5.6* | *4.9* | *5.5* | *6.3* | *5.9* | *6.9* | *4.1* | *3.6* | *2.3* | *1.6* |
| *Maize* | *2.2* | *2.1* | *2.0* | *2.3* | *2.1* | *1.9* | *1.7* | *1.9* | *1.5* | - | *2.0* | *1.3* |
| *Wheat meal and flour* | *2.6* | *2.3* | *2.3* | *2.1* | *1.6* | *1.0* | *0.8* | *0.6* | *0.5* | *1.0* | *0.3* | * |
| Raw cotton | 10.8 | 10.6 | 8.5 | 7.2 | 8.7 | 10.0 | 10.1 | 6.0 | 4.6 | 6.2 | 1.3 | 0.6 |
| Meat | 6.3 | 6.6 | 7.5 | 8.7 | 9.1 | 7.9 | 7.1 | 9.2 | 12.2 | 7.8 | 7.9 | 5.8 |
| *Fresh beef and mutton* | *0.8* | *1.2* | *1.9* | *2.4* | *2.9* | *3.0* | *3.2* | — | *5.5* | *1.0* | *2.8* | *1.1* |
| *Bacon and hams* | *2.3* | *2.3* | *2.6* | *2.9* | *3.1* | *2.8* | *2.5* | *3.8* | *4.5* | *2.4* | *2.1* | *1.9* |
| *Animals* | *2.4* | *2.2* | *2.1* | *2.2* | *1.8* | *1.1* | *0.2* | *1.4* | *1.2* | — | — | *0.8* |
| Wool, sheep, alpaca, etc. | 6.2 | 6.6 | 6.3 | 5.1 | 4.0 | 4.9 | 4.6 | 6.1 | 4.9 | 7.3 | 3.0 | 1.5 |
| Butter and margarine | 2.9 | 3.2 | 3.9 | 4.0 | 4.3 | 4.1 | 3.8 | 4.2 | 5.2 | 3.5 | 3.0 | 2.3 |
| Wood, total | 4.1 | 4.0 | 4.0 | 5.0 | 4.6 | 4.1 | 4.0 | 3.7 | 4.4 | 3.5 | 4.3 | 3.0 |
| Sugar | 5.6 | 4.6 | 4.7 | 3.7 | 3.2 | 3.3 | 3.4 | 2.0 | 2.0 | 3.1 | 1.4 | 1.6 |
| Rubber | 0.6 | 0.7 | 0.8 | 1.2 | 1.3 | 2.2 | 2.8 | 2.0 | 0.9 | 2.3 | 1.4 | 0.7 |
| Silk yarn and manufactures | 2.8 | 2.9 | 3.1 | 3.5 | 2.5 | 2.1 | 1.9 | 1.2 | 0.6 | * | — | 0.2 |
| Oil, seeds and nuts | 2.1 | 1.9 | 1.7 | 1.4 | 1.6 | 1.9 | 2.0 | 1.6 | 1.5 | 8.2 | 1.2 | 0.6 |
| Hides, skins and furs, raw | 1.7 | 1.6 | 1.6 | 1.5 | 1.4 | 1.8 | 1.8 | 2.2 | 2.1 | 1.9 | 1.0 | 0.8 |
| Tea | 2.7 | 2.6 | 2.4 | 2.2 | 1.7 | 1.7 | 1.8 | 3.1 | 3.6 | 2.2 | 2.6 | 1.6 |
| Chemicals | 2.9 | 3.0 | 2.1 | 1.8 | 1.7 | 1.7 | 1.7 | 1.3 | 1.0 | 1.4 | 3.8 | 5.1 |
| Fresh fruit and nuts | 1.1 | 1.2 | 1.4 | 1.5 | 1.7 | 1.7 | 1.5 | 2.8 | 4.0 | 3.6 | 2.5 | 5.0 |
| Woollen yarn and manufactures | 2.1 | 2.8 | 2.9 | 2.6 | 2.4 | — | — | 0.9 | 0.6 | * | 0.1 | 0.2 |
| Cotton yarn and manufactures | | | 1.0 | 1.2 | 1.4 | 1.6 | 1.6 | 0.9 | 0.5 | 1.1 | 1.3 | 0.6 |
| Leather | 1.3 | 1.5 | 1.7 | 1.7 | 1.5 | 1.5 | 1.5 | 1.3 | 1.1 | * | 0.6 | 0.4 |
| Iron and steel manufactures } Machinery | — | 1.1 | 1.0 | | | | | | | | | |
| Iron and steel manufactures | | | | 1.2 | 1.5 | 1.3 | 1.8 | 2.3 | 1.5 | 1.0 | 2.0 | 1.9 |
| Machinery | | | | 0.6 | 0.8 | 0.8 | 0.9 | 1.5 | 1.6 | 1.7 | 5.6 | 8.0 |
| Eggs | 0.7 | 0.8 | 0.9 | 1.0 | 1.2 | 1.1 | 1.2 | 1.5 | 1.2 | 1.0 | 1.0 | 0.7 |
| Flax and hemp, raw and tow | 1.4 | 1.4 | 1.2 | 1.1 | 1.3 | 1.1 | 1.1 | — | — | * | — | — |
| Cheese | 1.2 | 1.1 | 1.2 | 1.2 | 1.2 | 1.1 | 1.0 | 1.2 | 1.1 | 1.0 | 0.7 | 0.7 |
| Tin | 0.6 | 0.7 | 0.6 | 0.9 | 0.9 | 1.1 | 1.2 | 0.8 } | | * | 0.5 | 0.4 |
| Copper | 0.6 | 0.7 | 0.5 | 0.8 | 0.9 | 1.1 | 0.9 | — } | 1.8 | 1.8 | 2.8 | — |
| Iron ores | 0.6 | 0.7 | 0.7 | 1.0 | 0.9 | 0.9 | 0.9 | 0.4 } | | 1.5 | 1.4 | 1.0 |
| Petroleum | — | — | — | — | — | — | — | 3.2 | 4.2 | 5.9 | 11.9 | 11.1 |

* Less than 1 per cent.

shipbuilding industry, but made it possible to offer very low rates for suitable return freights, e.g. iron ore.[1]

We see, then, that after the Industrial Revolution, the import trade assumed the general features that continued to characterise it for a century, showing an overwhelming importance of the imports of raw materials and foodstuffs, with raw cotton rivalling grain and flour for first place by value; and an export trade that apart from coal was primarily in the products of the textile and metallurgical industries. It would indeed have been very difficult for a citizen of Victorian England to imagine that by the late 1960s the two most important items on the import list would be petroleum and machinery, with cotton manufactures and coal reduced to complete insignificance amongst the exports. We may briefly examine the world setting in which these fundamental changes have taken place.

## The changing pattern of British trade

As British trade expanded during the nineteenth century it became a characteristic feature that, year by year, the value of imports greatly exceeded that of exports. The difference was made up by what are known as 'invisible exports'. Under this heading the principal receipts were interest on overseas investments, profits from banking and insurance business overseas, payments for services rendered by British technicians and other exports abroad and receipts from shipping and the carriage of goods. All over the world, especially in the so-called 'new' countries, Britain had built and owned railways and ports together with such public utilities as gas, electricity and water supply companies; mining and other companies working natural resources such as timber; in every city in the world British banks and insurance offices were to be found and innumerable commercial companies. Half the world's shipping, carrying at least half the world's passenger and freight traffic, was British whilst British technical experts were to be found in every country in the world. The receipts from all these varied sources came to the home country not as money but as goods—especially foodstuffs, and raw materials—which thus flowed automatically into the country. Indeed at times the flow threatened to become a flood and both raw materials and manufactures were dumped at prices undercutting the home producer. Overseas countries anxious to buy British manufactures sold their foodstuffs to us at under cost. Such manufactured goods as Japanese silks sold at less in the shops here than in Japan.

Whilst it was clear that such a trade pattern could not last indefinitely it was the Second World War which completely changed the whole position.

Already and at an increasing pace as the newer countries of the world grew and developed they sought to control their own affairs—either for the state to take over such essential services as railways or for companies con-

1. On some aspects of this subject, see A. J. Sargent, *Seaways of the Empire*, 2nd edn, 1930.

trolled by their own nationals to replace the foreigners. While the foreigners—the British in so many cases—were usually compensated, the source of their income disappeared. Further, all countries in the world were tending towards industrialisation—the home production of manufactured goods—often in factories equipped with British machinery and staffed by those trained in Britain or by British technicians. When the Second World War cut off supplies from Britain there was added a final incentive to the development of the home countries' resources.

Thus Britain emerged from the Second World War with many, one may say most, of her overseas investments sold, a large part of her banking and insurance business passed into other hands, a large proportion of her merchant shipping at the bottom of the sea, a large number of her old customers either supplying themselves or buying from other sources—especially the United States. Broadly speaking Britain was faced with the task of paying her way, selling exports of manufactured goods in sufficient quantities to pay for the import of raw materials and the 45 to 50 per cent of food which is not, and can scarcely be, home-produced. In all the markets of the world British manufactured goods have to compete both with the home-produced article and with those from other exporting countries such as the United States and the older countries of Europe including (since her recovery from the war) her old rival Germany. When she has succeeded in selling her exports, which can only be by superior quality and lower prices than rival products, Britain has to buy her raw materials in the world's markets in competition with other buyers, often for surpluses far less abundant and more costly than in the past. Some countries, to protect their own industries, put up barriers in the form of import duties and other restrictions including currency restrictions. Britain in her turn must restrict imports for which she cannot pay—in particular from dollar countries.

The world has thus become divided into a number of trade regions—or alternatively the countries of the world may be said to have become linked into a small number of groups. These are:

(*a*) The Soviet bloc, or the USSR and the Comecon countries, including Poland, Eastern Germany, Hungary, Romania, Bulgaria and Czechoslovakia. China may perhaps be included with this group.
(*b*) The Sterling Area (now officially called the Scheduled Territories) comprising the Commonwealth, except Canada, together with those countries which have linked their currency with the pound sterling.
(*c*) The Dollar Area, primarily the United States and those countries which are linked financially to the United States dollar.
(*d*) The European Economic Community, often called the Common Market, brought into being on 1 January 1958 by a treaty signed in Rome the previous year, and consisting of France, West Germany, Italy, Netherlands, Belgium and Luxembourg.
(*e*) The European Free Trade Association (EFTA or 'the Seven') came

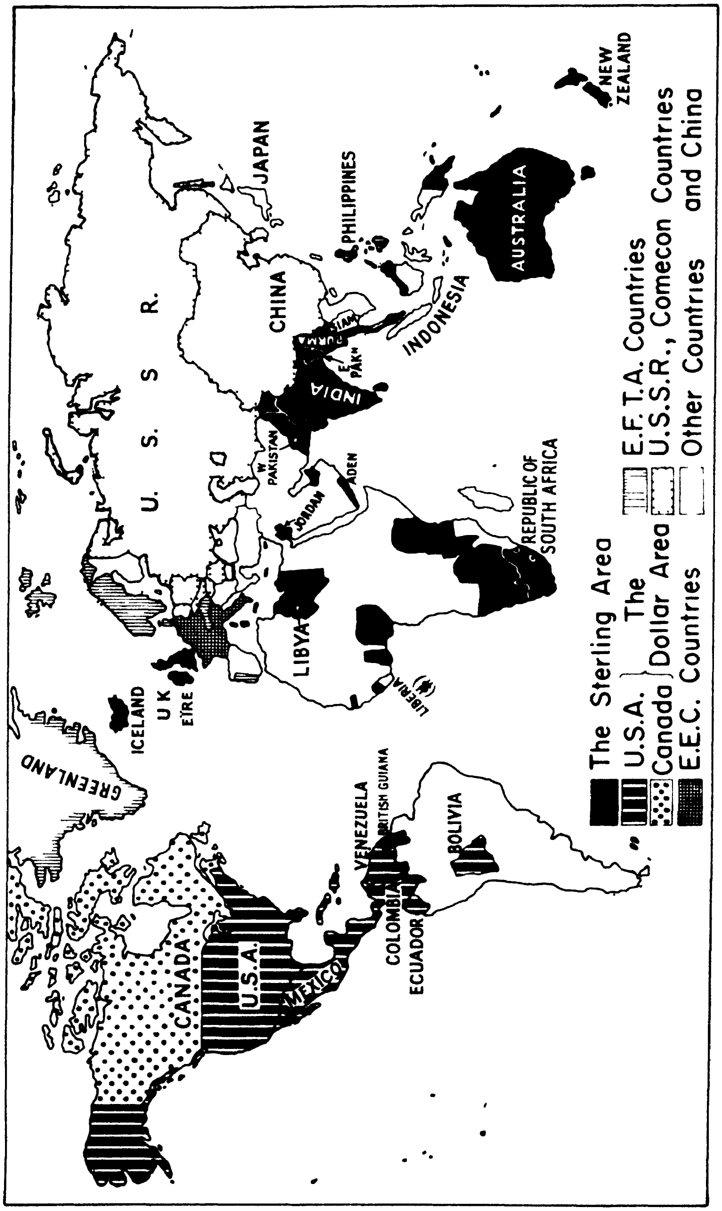



FIG 280 Map of the world showing the Soviet Bloc behind the Iron Curtain, the Sterling area, the Dollar countries, the European Economic Community or Common Market and the European Free Trade Area (EFTA comprising the United Kingdom, Austria, Denmark, Norway, Sweden, Portugal and Switzerland, Finland is an Associate Member)

into being in 1960 and consists of the United Kingdom, Austria, Switzerland, Portugal, Denmark, Norway and Sweden with Finland joining in 1961.

The relative importance of the 'blocs' in British trade is shown in Figs 289 and 290. For fourteen years, 1947–61, most of the countries of Western and Central Europe were linked as the OEEC countries (Organization for European Economic Cooperation), the members of which received American aid in their postwar rehabilitation.

There is relatively little foreign trade between the Soviet countries and the outside world so that this bloc is almost self-contained. The countries of the sterling area trade with one another with relative freedom and funds

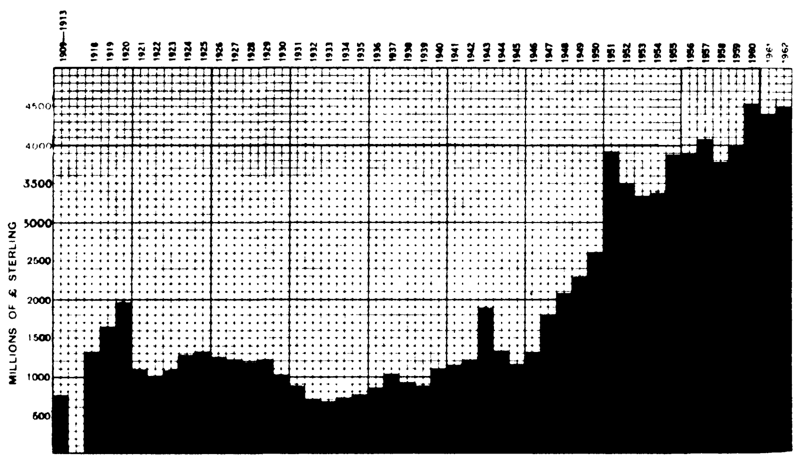



FIG. 281. The fluctuations in the declared value of imports into the United Kingdom

This diagram ignores the change in the value of money, and should be compared with the table showing the changing volume of trade

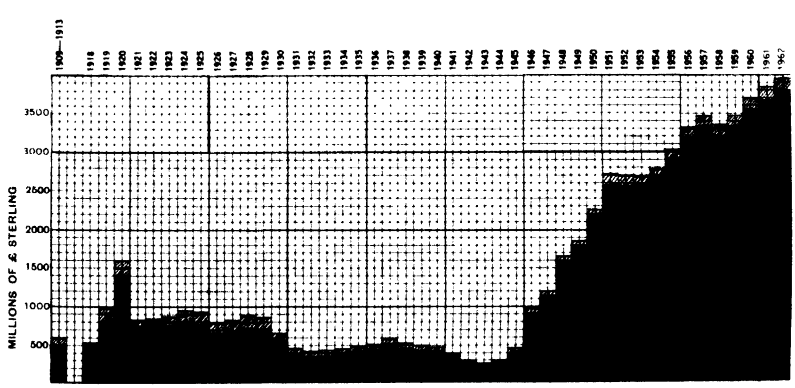



FIG. 282. The fluctuations in the declared value of exports from the United Kingdom. Exports of home origin shown in black; re-exports lined

can be sent from one country to another, but the group as a whole tries to limit purchases from dollar countries and to conserve its gold and dollar reserves.

In the early part of the present century, invisible exports accounted for over 30 per cent of the whole of British exports. This figure dropped to 20 per cent in the interwar period and became almost negligible during the Second World War. In the 1949–51 period it recovered to about 3 per cent, exceeded 10 per cent in 1953–54 but, as a net figure, has since dropped.

When pound notes were first introduced to take the place of gold coins, they were freely exchangeable for the actual gold coins by those who wished to do so. This has long since ceased to be the case and in 1952 a gold sovereign had become worth nearly £3 in notes. The value of the old pound had thus become reduced to about 6*s* 8*d*. Other currencies in other countries had suffered still more severely: before 1914 the French franc was worth nearly 10*d* in British money; in 1953 it had become worth less than ¼*d* even in terms of the lowered value of the British penny. It follows that it is now useless to compare the value of British trade, either imports or exports, with previous years over any considerable length of time. The changes in such commodities as coal or iron and steel may best be seen by comparing weights, but of course this cannot be done for trade as a whole involving as it does a wide range of commodities. Changes in quality may make it difficult to compare

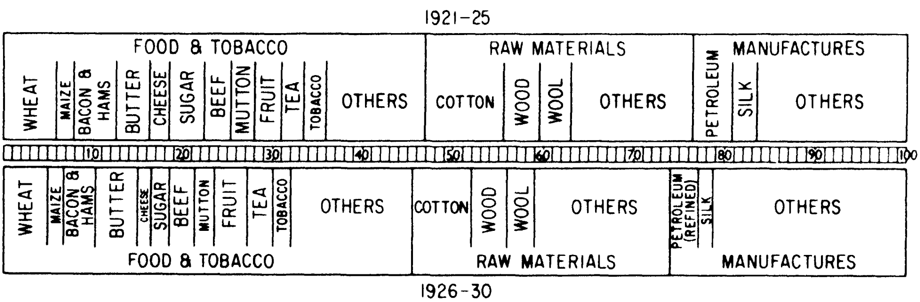



FIG. 283. The interwar trade of the United Kingdom—imports

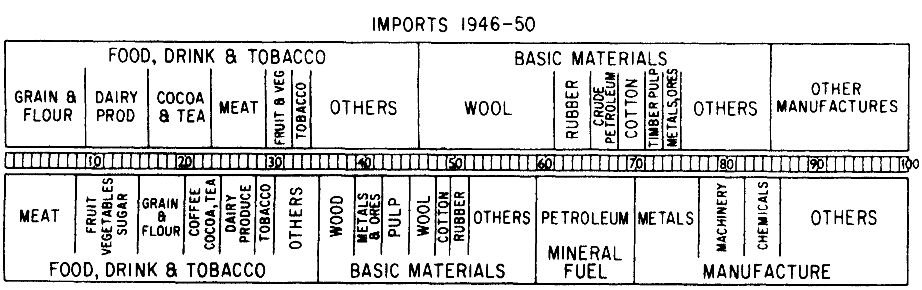



FIG. 284. The postwar trade of the United Kingdom—imports

quantities directly in many cases. In order to make comparisons possible various systems and series of index numbers may be used. One year may be taken as a standard or starting point and later years expressed as percentages of that standard, taking into account changes in the value of money. The Board of Trade, taking first 1938 as the standard (= 100), showed that in 1947 imports had dropped to 78 but exports of British origin had risen to 109. Re-exports, after dropping to 5 in 1942 had recovered to 45. The Board of Trade then took 1947 as a standard year and showed a rise from 100 to 144 for imports in 1957 and of exports from 100 to 184. The year 1954

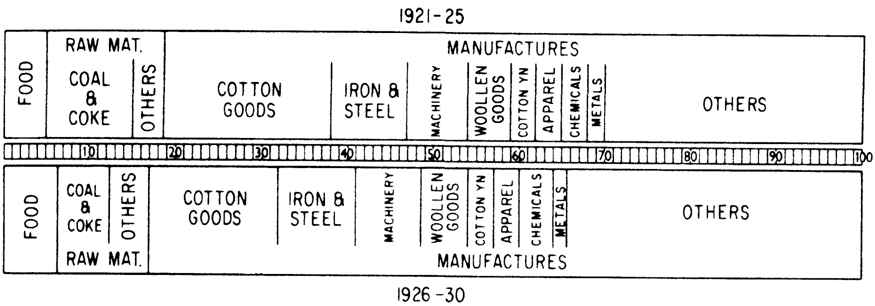



FIG. 285. The interwar trade of the United Kingdom—exports

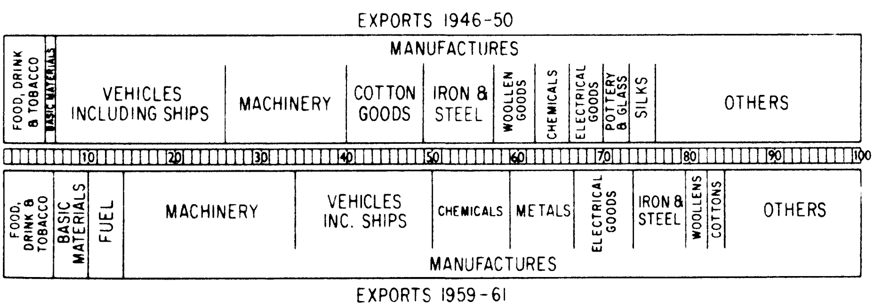



FIG. 286. The postwar trade of the United Kingdom—exports

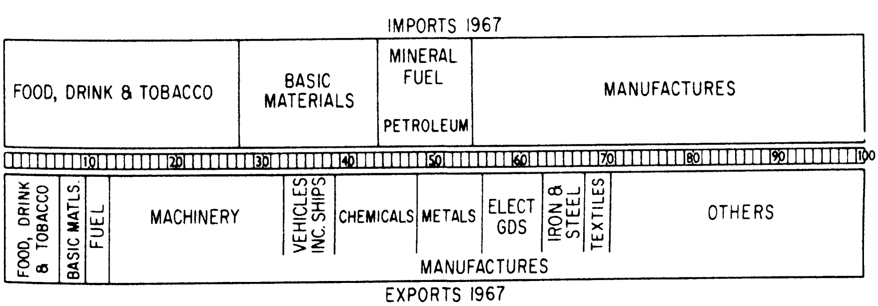



FIG. 287. Imports and exports, 1967

was the next standard used (= 100). By 1961 imports had climbed to 135, exports to 125. Then, using 1961 as a standard, imports had climbed by 1967 to 109, and exports to 114.

The diagrams illustrating this chapter express the main categories of imports and exports as percentages of the whole and so enable changes in the relative importance of any individual commodity or group of commodities to be compared. Similarly the direction of foreign trade can be compared with past years.

## The United Kingdom and world trade

Although it is difficult to get figures on a comparable basis from all countries, it is possible to measure at least approximately the value and volume of British trade against world trade as a whole. In this table the year 1913 is taken as one of a peak in British trade before the First World War (when British coal exports were at their maximum); 1931 is representative of the great depression, and 1950 of the period immediately following the Second World War.

*World trade 1913–67*

| COUNTRY | RETAINED IMPORTS | | | | DOMESTIC EXPORTS | | | |
|---|---|---|---|---|---|---|---|---|
| | 1913 | 1931 | 1950 | 1967 | 1913 | 1931 | 1950 | 1967 |
| United Kingdom | 16 | 22 | 12 | 9 | 14 | 12 | 11 | 7 |
| United States | 9 | 12 | 16 | 13 | 13 | 15 | 18 | 16 |
| Germany | 14 | 9 | 5 | 9 | 12 | 15 | 4 | 11 |
| France | 8 | 9 | 5 | 6 | 7 | 8 | 5 | 6 |
| Other countries | 53 | 48 | 62 | 63 | 54 | 50 | 62 | 59 |
| | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

It will be seen that up to the period of the Second World War Britain was taking a larger and larger proportion of imports, but already contributing less to the sum total of world exports. In the post-war period the recovery of Germany contrasts with the declining position of Britain.

## Trade in certain industries

The trade in many industries has been dealt with in the appropriate chapters. Some general points of interest may be recalled here.

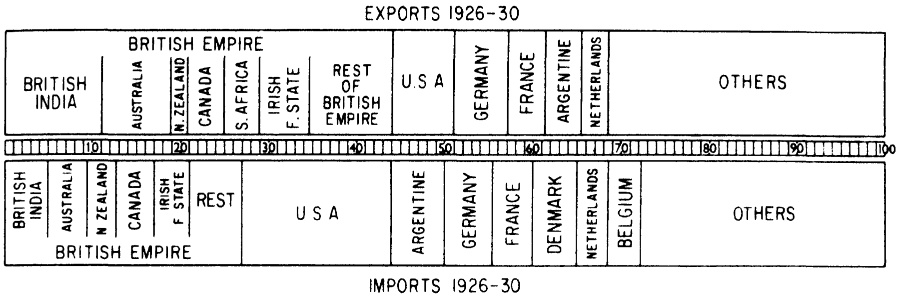



FIG. 288. The direction of foreign trade, 1926 30

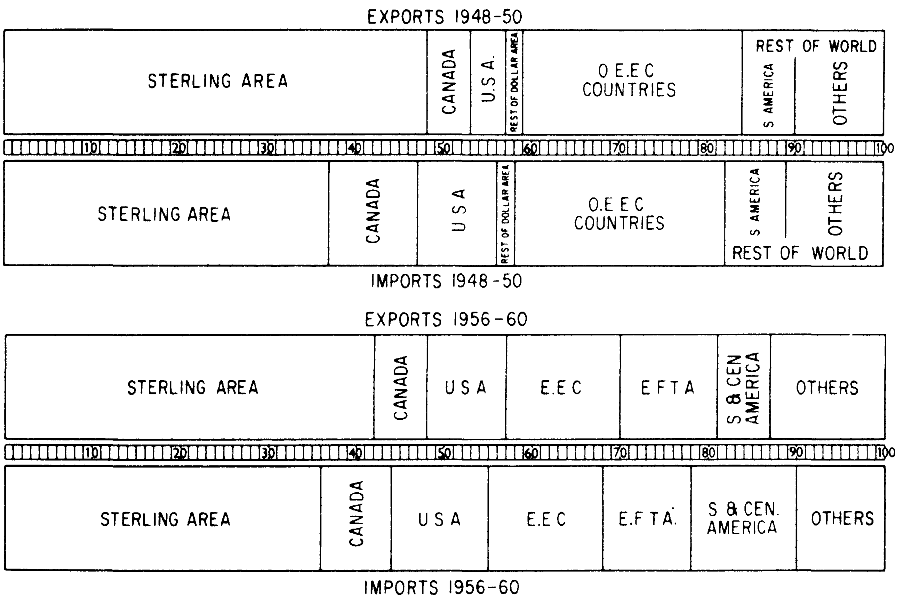



FIG. 289. The direction of foreign trade, 1948 50 and 1956–60

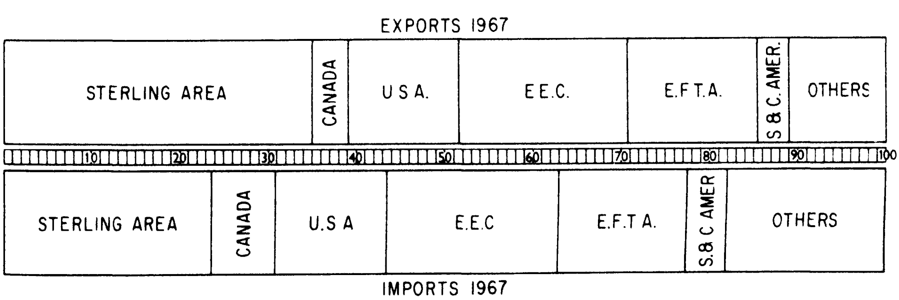



FIG. 290. Direction of trade, 1967

## The textile industries

During much of the nineteenth century textiles dominated British foreign trade—on the one hand import of cotton, wool and other raw materials, on the other hand the export of cotton manufactures, woollen manufactures, linen, silk and other goods. The long-maintained supremacy from 1881 to 1913 is well seen in the summary tables above. Even in 1924 textile materials constituted some 52 per cent of the value of retained imports of raw materials, and goods made from the materials contributed 37 per cent of the value of all British exports or 48 per cent of the value of all British manufactures exported. Or again in 1931 the figures were 39 per cent of the value of imports of raw materials and 25 per cent of all exports. By 1952 the corresponding figures had fallen to 13 per cent of imports and 15 per cent of exports. In 1913 *cotton* yarns and manufactures alone formed nearly a quarter of the value of *all* exports. By way of contrast in 1952 imports of raw cotton had fallen to less than 4 per cent of the total value of imports; cotton manufactures to less than 6 per cent of exports. As shown in the tables above the fall has continued; raw cotton to 0.6 per cent of imports, cotton manufactures to 0.5 per cent of exports in 1967. The reasons are many and cumulative; there is no hope that the cotton industry will ever regain its old position (see Chapter 20). The other textiles have also declined—woollen manufactures from 10 per cent around the turn of the century to 1.5 per cent in 1967, linen from 2.5 per cent to 0.1 per cent, and silk from 0.7 to 0.03 per cent. To a limited extent, however, the rise of exports of manmade fibres and manufactures thereof has compensated for the decline in the other textiles (cf. Fig. 202).

## The metal industries

Metals, manufactures therefrom and engineering products account for about half of all British exports. The emphasis is naturally upon the export of manufactured goods upon which much skill has been expended. By far the largest single item in the entire export list is motor-cars, with aircraft and aircraft engines very high in the list and commercial vehicles and tractors making an important contribution. Indeed, if 'engines' are transferred from the 'machinery' category in which they are shown on Fig. 287, the total contribution of the motor and aircraft industries to the export trade in 1967 was nearly 13 per cent. Finished steel in many shapes and forms occupies a high place, as do various non-ferrous metals. Electrical goods of many kinds, from power plant, switchgear and cables to radio and electronic equipment, are important, and prominent places in the 'machinery' group are occupied by textile machinery, office machinery (typewriters, calculating machines, etc.) and earth-moving machinery.

## Other manufactures

On the export side, the sales overseas of chemicals, drugs, dyes and colours account for nearly 10 per cent of total exports—more than ten times that of

pottery, glassware, and china. An interesting recent change is the jump in export of refined petroleum products. The list of miscellaneous manufactures exported is very long—ranging from heavy bulky commodities like cement from home produced raw materials, and asbestos, from entirely imported, to plastic goods, floor coverings, jewellery, toys, paper, books and curios.

On the import side manufactured and semimanufactured goods have been increasing rapidly in recent years, and whereas in the early 1950s they represented between 20 and 25 per cent of the total value of imports, by 1967 this figure had risen to 45 per cent (Fig. 287). Semimanufactures comprise non-ferrous metals, chemicals, plastics, etc., whilst in the fully-manufactured category machinery, including electrical apparatus and transport equipment, bulks largely, with clothing and wood manufactures as other important items.

## Food, drink and tobacco

The trade here is largely on the import side, and includes wheat, maize, meat, butter, cheese, eggs, fresh fruit and vegetables, sugar, molasses, preserved, dried and tinned fruit, tea, coffee, cocoa and tobacco. The increasing affluence of the British people has resulted in a number of recent changes, including a substantial increase in the relative importance of fruit imports (see table on p. 803) and the doubling of the wine imports in less than a decade. But there is also an export, reaching between 6 and 7 per cent of total exports. The largest single item is Scotch whisky (13 million gallons valued at £36m in 1952, rising to 30 million gallons valued at £80m in 1961 and 48 million gallons valued at £132m in 1967), which goes mainly to North America; others include refined sugar, chocolates, cigarettes, and in some years a substantial quantity of barley.

## Raw materials

The virtual disappearance of the coal export trade has already been emphasised. The replacement of the former very large import of refined petroleum products by a huge increase in crude petroleum marks an important new industrial development (cf. p. 353). China clay is now the only important raw material export ('Basic Materials' on Fig. 287). Most of the varied raw materials imported go directly to feed British factories—the textile materials, timber and pulp, rubber, hides, skins, furs, vegetable oils and oil seeds, and whale oil. The great expansion of British iron and steel is dependent not only on the imports of iron ore, but also on tungsten, manganese, and nickel for the manufacturing alloys. The home production of metalliferous non-ferrous ores now being negligible, the great non-ferrous metal industries depend upon imported zinc, aluminium, copper, lead and tin as well as several minor metals.

## The entrepôt trade

The entrepôt trade suffered severely from the partial destruction of the Port of London during the Second World War. It has recovered, and continues to be dominated by London's seaport and airport (cf. pp. 715 and 719); its monetary value has continued to increase, but its value relative to the export trade has declined, from 5 per cent in 1952 to 4.1 per cent in 1961 and 3.6 per cent in 1967. Outstanding items are rubber, wool and raw furskins, with tea, coffee, spices, tobacco and non-ferrous metals. More than half the re-exports are destined for western Europe.

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The detailed study of the physiography and geomorphology of the British Isles has not yet been fully undertaken on a uniform plan. There are, of course, innumerable accounts of the physical features of the islands on general lines, and incidental accounts of local details will be found especially in the *Memoirs* of the Geological Survey and the geological papers in the Quarterly Journal of the Geological Society and the Proceedings of the Geologists' Association. Amongst other contributions of importance, with details of physiography, apart from those cited in the text, are the following:

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Founded in 1860 the British Rainfall Organisation was a voluntary organisation until the retirement of Dr Hugh Robert Mill in 1919; the carefully compiled annual volumes of *British Rainfall* are a mine of information. For modern advances in knowledge constant reference should be made to the *Quarterly Journal of the Royal Meteorological Society* and to the popular monthly, *Weather*, also published by the Society.

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*Addenda*

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